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REPAIR OF THE COMMON BILE DUCT*

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FOLLOWING a precedent early established in this Association, the Chairman's address has involved the presentation of some living problem of surgical interest. Permit me this morning, therefore, to invite your consideration of the still debatable question of Common Bile-duct Repair. My remarks will be accompanied by some X-ray photographs illustrative of the method advocated. Several years more experience with a procedure advocated by me elsewhere, serves to confirm the speaker's convictions—that while not yet perfect, it offers the most rational and efficient method yet devised for the correction of these most distressing complications in bile-tract surgery, stricture, or loss of continuity. Disease, accident, or neoplasm may result in such stricture or loss of continuity of this duct as will compel efforts on the part of the surgeon to reëstablish a permanently patulous channel for the free flow of bile to the duodenum or the stomach. The procedure is necessarily modified by the causative factor in its destruction, the location of loss of lumen, and the condition of the surrounding field of operation. Unfortunately, it occurs so much more frequently as a sequel to former surgical invasion of the bile tracts for disease and resultant stones, that a certain stigma rests upon the surgeon, though generally unmerited.

Search through the literature reveals many methods that have been suggested for the relief of this condition, the majority affording only indifferent success. Ellsworth Eliot has made a masterly review of the entire subject. Here, in the home of bile-duct surgery, *particularly* must attention be called to the recommendation of Dr. William Mayo, who has successfully reconstructed the missing portion of the duct out of a tongue-like flap of all three layers of the adjacent bowel or stomach, converting it into a tube: its free end has been sutured to the proximal end of common duct, and the opening in the hollow viscus closed as thoroughly as possible about the base of the pedicle. Walton has made similar recommendations, and finds no harmful effects when using the stomach as the site of drainage. Hertzler has utilized a portion of the gall-bladder, so cut as to supply a tubular flap to repair duct; but the gall-bladder is usually absent in cases requiring repair, and when present can be more simply used by an anastomosis with the duodenum direct, thus making a by-pass for the bile.

* Presidential address, delivered before the American Surgical Association, May 31, 1923.

Fascial transplants have been used with occasional success in the animal experimentations, but all too frequently result in failure when the same are utilized in the pathological common duct. The earliest recorded case of an attempt to reconstruct over a tube a common duct I could find was that of Jenckel, November, 1905, who endeavored to reconstruct a duct by suturing one end of a rubber tube in the common duct, then inserting the other end in the duodenum after the Witzel method for *temporary* gastric or jejunal fistula, that is, by burying the tube by suture in a fold of the duodenal wall for one or two inches before perforating that wall. The chief value and point in Witzel's procedure was to produce a temporary channel that would close with the removal of the tube. The very thing to be avoided then in establishing a new common duct! In fact, in the case mentioned, Jenckel, three weeks after operation, inserted his finger into the fistulous tract to remove the tube. Traction on it tore open the duodenum along the Witzel suture, with a resulting desperate duodenal fistula, and extremely tedious convalescence. Strangely enough, after months, the wound epithelialized sufficiently internally before it closed externally to establish a nexus between proximal stump of duct and duodenum! After more than a year's time, the patient was discharged cured.

FIG. 1.—Schematic drawing showing catheter placed in common duct through both proximal and distal ends into the duodenum.

In October, 1907, I relieved temporarily a chronic intermittent jaundice with fistula, by excision of the fistula, removal of a somewhat dilated remnant of a cystic duct with stones, and removal of stones and grit from the common duct at the junction of cystic with common. A probe passed down freely into duodenum, and when palpated revealed the distal portion of duct surrounded by much indurated and cicatricial tissues. Duct was dilated above site of stones, but being patulous to fluids and to probe, no effort was made to dilate the narrowed portion. A small soft rubber catheter was passed down the duct well into the duodenum and the wound closed about the catheter. Recovery uneventful: healing in seven weeks.

Nine months later, after several recurrent attacks, chills, fever, and jaundice, patient was reopened. Stricture found about site of former opening, the duct this time being opened nearer duodenum. Probe passed easily downwards through ampulla: efforts to pass same upwards met with failure, except

with fine Bowman's probe. Splitting of stricture and excision of scar-tissue revealed duct dilated above to easily admit No. 16 English sound. Insertion upward in proximal dilated duct of a rubber tube was made, the end of which had a double revers cuff enlargement, and fastened in place by a twenty-day chromic encircling suture. The free end of the tube was carried well into the duodenum through the distal duct and ampulla, so that six to eight inches protruded into the duodenum: the ends of duct were approximated with fine catgut sutures. Wound closed with cigarette drain down to line of duct suture. No bile leakage through wound.

FIG. 2.—Shows X-ray picture of tube in the common duct. This was one of the earlier cases operated and took nine weeks to be discharged via the intestines.

At this point, let me express the agreeable surprise that has been mine in most of these cases, namely, that the majority of them have leaked no bile at all, though there had been no thought of a hermetic suture, as evidenced by the fact that drainage was always provided for. With the flow so freely possible through the catheter into the duodenum, it would appear that there existed an almost negative pressure in the common duct. This has been equally true when unable to find or utilize the distal portion of the duct, the catheter has been inserted through a simple opening in the wall of the duodenum and held there with a double purse-string suture of silk, tied tightly enough to be temporarily hermetic, sutures to be finally cast off with the catheter. Every justifiable effort, however, should be made to find the distal end of common duct before resorting to the direct union of the proximal end of the duodenum, because of the potential danger of an ascending cholangeitis. One of this series, while absolutely free of jaundice, has from time to time chills, fever, malaise, lassitude, and all the signs of a cholangeitis without bile in urine, skin, or sclera, and with normal stools.

Returned home in five weeks. All symptoms disappeared. Tube passed per rectum thirty-three days after insertion. Seven other cases have since been so treated with satisfaction.

Two years later, the excellent experimental work of Sullivan demonstrated the possibility of successful reconstruction of the resected common ducts in animals, by the insertion and maintenance there within the lumen of the ducts of rubber tubes during the time necessary for epithelization. These experiments resulted in the evolution of the T or fishtail tube, and Sullivan had

successful cases to report in the human in 1912. At a clinic given for the American Society of Clinical Surgery at Heidelberg, Germany, by Professor Wilms in the summer of 1912, we were shown as a recent discovery by him how to utilize a rubber tube for the purpose of repairing common duct defects!

Following Sullivan's early recommendations, came many successful applications in practice, usually with some means for the removal of the tube when it had completed its work. The well known T tube, having demonstrated the possibility of repair, has (like the Murphy button) given place to other methods, and for these reasons:

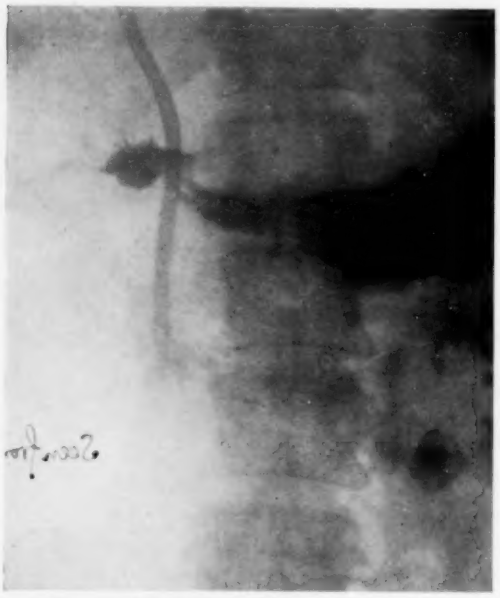

FIG. 3.—Shows tube in common duct and duodenum taken with barium meal in stomach and shows relationship of tube to pylorus and duodenum. This tube also shorter than those now recommended.

1. That in the effort to remove it, the short end of the T has several times been torn off instead of pulling through the opening of the common duct, or,

2. Has so torn the duct as to reproduce the original stricture.

Tying a strong ligature to the tube within the duct, by which it may later be forcibly removed through the wound is open to same objection. Leaving a short tube permanently in place in the duct itself is to be condemned because of the ultimate deposit of bile with recurrence of symptoms, as in Case II of this series. In this case, I thought I had passed the tube through into the duodenum far enough to insure its escape by the alimentary tract, but operation one and one-half years later revealed bile deposit on the tube and in duct.

If there be one thing more than another that I desire to emphasize in this contribution to duct repair, it is this: that by the constant duodenal and jejunal "tug" upon a catheter inserted through the duct or side of the duodenum it will ultimately be drawn into the intestine and discharged per rectum. In the eight cases I have had, the shortest time of discharge has been twenty-seven days; the longest sixty-three. Hence we have a method of getting rid of a tube without a secondary interference. When, however, it has been deemed necessary to have it remain until the surgeon desires its removal, this has been readily accomplished by tying to the catheter a simple waxed silk ligature, which, brought out through the interval between the ends of the duct being repaired, is carried through a very small rubber tube reaching from the duct to the

surface of the body and fastened to an adhesive strip, the small tube covering the thread for its protective effect against cutting of tissues by the thread. When ready to cast off, the anchorage thread is cut at the surface of the skin. Within three to seven weeks, the catheter passes off through the alimentary tract, and the cure is completed.

This brings us to the question of how much of a gap between the distal and proximal ends can be thus repaired? Since by means of the anchoring thread we have a means of controlling the escape of the tube, it is simply a matter of judgment as to how long it will take the epithelium to grow between the two ends. No experiments of this nature are available; but in Case IV, where one-half to three-quarters of an inch had been excised, the thread was cut in four and one-half months, the catheter passing in five weeks, and the patient now well two years.

FIG. 4.—Shows another catheter passed down through common duct into duodenum. This was one of the cases anchored by a thread to the surface until epithelization of missing portion of duct had had time to occur. Thread cut at the end of four and one-half months; tube passed in five weeks. Patient well two years.

CASE REPORTS

CASE I.—G. L., a man of forty-eight (?), who, while seeking operation for a simple right inguinal hernia at a neighboring clinic, awoke to find that an appendectomy and the removal of a stone from the gall-bladder added to his herniotomy had been done. With a biliary fistula persisting for a year, he returned to the Clinic, when a cholecystectomy was done, with prompt recurrence of the biliary fistula. After another year's interval of alternate opening and closure, followed by jaundice and fever, he returned for the third time to the Clinic for search for the source of common duct obstruction. During this fourth interference, so severe a hemorrhage occurred as to make it necessary to desist, leaving the hæmostatic forceps *in situ* and packing the wound, returning the patient to bed to recover from loss of blood, shock, and so forth. The patient recovered and the wound healed (with the fistula persisting) and he returned home. While the fistula was draining, the patient was comfortable; when closed for three or four days, there was recurrence of jaundice, chills, fever, and common duct symptoms. After a lapse of several months, the patient was brought to the writer.

October 1, 1907. On this date and with the above history, an exploratory operation was made, following with great difficulty the course of the fistulous tract through a mass of adhesions of the stomach, liver, colon, and duodenum, to its source in a small remnant of the cystic duct, big enough to admit the index finger-

tip, and containing muco-purulent bile with black biliary grit. Splitting open this pouch and its communication with the common duct, the latter was found dilated above this point sufficiently to permit palpation of right and left hepatic branches; below this point, an average sized probe could be passed down into the duodenum. Two stones could be felt and they were removed from the dilated common duct, mixed with mucopus and grit. With the probe down the common duct, palpation revealed the duct, surrounded by much indurated cicatricial tissue, but, as the duct was patulous to probe and fluids, no effort was made to remove the narrowed portion or to divide the same. A No. 6 soft rubber catheter was passed down into the duodenum, and the wound was closed after excision of the remnants of the cystic duct.

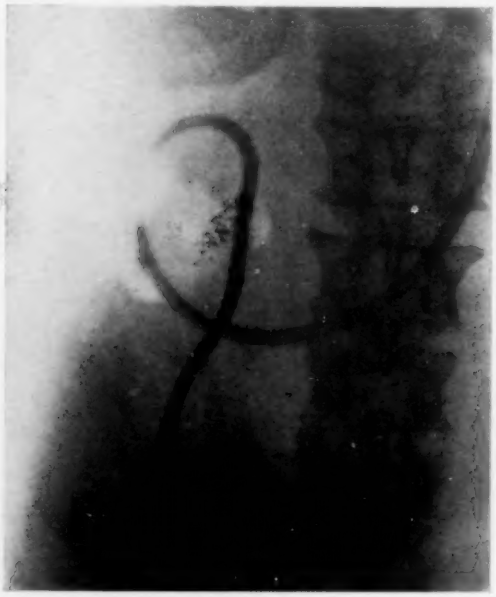

FIG. 5.—Shows catheter in duct and duodenum held in place by anchor suture to surface of the body eight weeks, at which time thread was cut.

Recovery was uneventful. The catheter was utilized while *in situ* to flush out the circulatory system and kidneys by introduction of two to three litres of sterile water daily into the duodenum, this clearing up the jaundice rapidly.

The patient returned home in seven weeks with the wound closed. On March 19th he writes as follows: "December, 1907, first week, wound reopened for several days. December 21st chills, fever, general aching, wound reopened. December 23rd, wound closed and has not reopened to March 19, 1908. No soreness or tenderness at site of incision; stools of good color up to time of attacks, then still yellow, but lighter; no colic at any time; no pains in shoulder or side; there is some jaundice and itching."

Between April and August, 1908, occasional repetitions of these obstructive symptoms, with septic reactions, led to the reopening of the wound on August 29, 1908, and the finding of a stricture below the formerly opened area, the common duct being this time opened nearer the duodenal junction. The probe passes easily into the duodenum. When trying to probe upwards, stricture found that admits only the smallest size probe. Divulsion of stricture and excision of scar-tissue sufficient to admit No. 16 English sound. On splitting open the stricture, several small black biliary calculi are discharged with free flow of bile. Insertion upward into dilated duct of rubber tube with double revers cuff; fastening same there with chromic gut, then passage of other end well down the duct into the duodenum so that six to seven inches are free in duodenal lumen. Wound closed with cigarette drain to junction of duct ends.

Healing uneventful; no bile escapes through wound; patient returns home in five weeks; all symptoms disappear.

November 1, 1908. Patient writes: "Tube passed this morning; sixty-three days since its insertion. Am better than I have been for three years."

November 21, 1909. Reports self better than for four years, after extended trip through West. Has none of the old symptoms.

The patient died some years later from a stomach carcinoma.

CASE II.—Mrs. B., entered St. Luke's Hospital, November 1, 1918, for obstruction of the common duct, with jaundice. Reopened the abdomen through old incision for cholecystectomy. No stones palpable in common duct. Pus, blood, albumen, casts (hyaline and granular) in urine. Quick insertion of two tubes at point of probable ligation of former cystic duct where stricture was found and split. One tube was inserted toward the liver in proximal end, and one downwards toward the duodenum, and the wound hurriedly closed, the aim being to relieve cholemia by the simplest procedure. Recovery was good, but there was some intermittent jaundice; itching was gone at the end of the week. One month later still she was somewhat jaundiced.

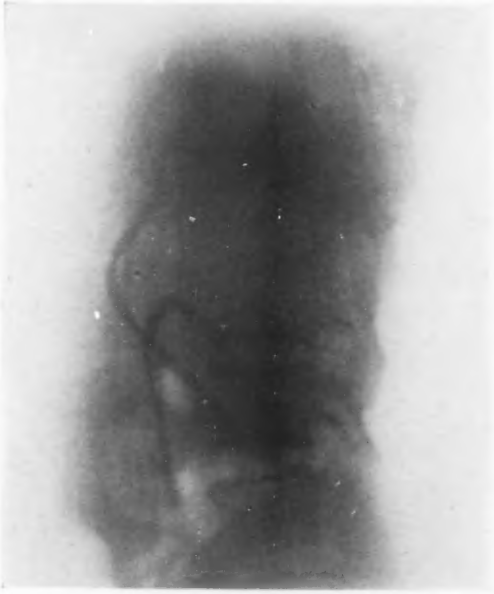

FIG. 6.—Lateral view of Case VI, showing unusual course of duodenum.

Second operation, December 23, 1918. Fistulous tract injected with methylene blue, and tract followed through adhesions to the common duct. Opening in it was enlarged sufficiently to insert a ⅜ inch rubber tube into the duct. On the upper end, a cuff or revers had been turned back in order to enlarge its calibre and retard its escape into the duodenum. The tube was about four inches long. The common duct was sutured over the tube at the slit in the stricture. The wound closed with drainage. Wound closed on the eleventh day. Stools became dark and urine light. Discharged nineteenth day (January 11, 1919).

CASE III.— Mrs. S., May 28, 1918. Typical history of biliary colics, nausea, vomiting, and jaundice. Gall-bladder was drained seven years before, after removal of stones by Dr. G. Reoperation revealed an hour-glass stricture of the gall-bladder. Compartment at fundus filled with stones below stricture (probable former purse-string site). The gall-bladder was thickened and infiltrated. The cystic duct was ligated with artery and vein, and cholecystectomy made. The drain was inserted down to the stump. There was free flow of bile on second day. The wound healed, and the patient was discharged July 23, 1918.

December 1st. The patient was sent to the hospital with a chill and fever; leucocytes 15,400, pulse 100; temperature 102.4, urine highly colored; stools light colored. The temperature was normal on the fourth day and the patient was discharged on December 7, 1918.

February 11, 1919. The patient returns to the hospital with jaundice, nausea, and vomiting; pruritus.

Operation.—The abdomen was opened through the old scar. The common duct was identified and opened. The probe passed downward easily into duodenum

without obstruction; passed upward to meet the obstruction near the hilus of the liver. The duct was split upwards along the probe to the obstruction, due to connective tissue constriction and scar-tissue. A portion of a small No. 7 soft rubber catheter was inserted with funnel, and was inserted above the constriction, and the other end was passed down into duodenum and then closed over catheter, and a Bullitt drain inserted to the field of the suture. Drain was removed on the seventh day, February 18th, stools normal on the second day. The patient returned home, healed, on March 3, 1919.

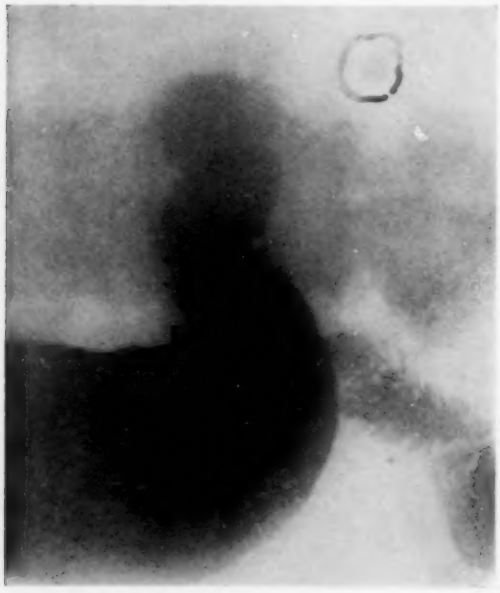

FIG. 7.—Illustrates a new id to diagnosis of nature of obstruction in common duct. If the patient be studied fluoroscopically by lateral view during the passage of barium through the duodenum, it is many times possible for the röntgenologist, by massaging the duodenum, to make the barium enter the lower end of the common duct; if stone be present, to so coat the stone with barium that it will then show for many days in an X-ray picture. A stone endeavoring to escape from the common duct is probably preceded by a relaxation of the distal end of the duct, similar to the softening and relaxation that occurs in the uterine cervix with the descending head of child. I would ask the members in their future cases of suspected common duct stone obstruction, to test out this observation, as I believe they will have frequent gratifying confirmation of their suspicions. Emphasis must be laid upon the need of lateral observation of the patient, because the common duct enters into the duodenum posteriorly and such a condition could not be seen through the full duodenum.

After one and three-quarter years of comparative comfort, the patient again showed jaundice. On December 14, 1920, the abdomen required reopening. The common duct was reached through the adhesions without seeing free peritoneum. Opening the same, revealed a black silk suture as the nucleus of a gall-stone at site of former stricture. It was deemed advisable to suture the proximal end of the common duct to the new opening inside of the duodenum. This was done by inserting a purse-string suture in the duodenal wall, passing nearly the whole catheter down the duodenum through the small buttonhole incision and tightening the purse-string suture. The funnel end was inserted in the proximal end of the common duct above the stricture, and the common duct end was sutured to the duodenum by four fine silk sutures. A drain was inserted to the bottom of the wound and removed on the seventh day. The patient was discharged on December 30th. Tube passed the 27th day.

CASE IV.—Mrs. M., December 30, 1912, aged twenty-nine, married. The patient was operated on ten months ago for gall-bladder disease; then again six weeks later. For four months there were intermittent jaundice, pain, and vomiting, and the stools were clay-colored. Stricture of the common duct was found and opened. A tube was inserted with the cuff turned back for the proximal end; the other end was carried down into the duodenum; the duct was sutured over it; the wound was closed with drainage. Recovery was prompt, with relief of symptoms. The tube passed in nine weeks.

CASE V.—Patient aged thirty, married, two children. There was frank gall-stone disease, associated with occasional jaundice. No previous operations.

Operation on June 9, 1921 at St. Lukes Hospital. The simplest type of cholecystectomy was done, following the best known technic of subperitoneal resection of the cystic duct after satisfactory isolation and identification of both artery and duct. I never did a more comfortable, easy cholecystectomy. There were many stones. After the wound was closed and the patient was in bed, inspection of the specimen showed a peculiar ¼ inch tubular structure attached to one side of the cystic duct portion of the gall-bladder. Immediate frozen section showed it to be lined with epithelium similar to the duct. I immediately realized my mistake, told the family physician, (who had watched and complimented the careful operation) and the relatives frankly what had happened and explained the necessity of immediate opening of the wound to resuture the duct. This was done. The ends of the duct were picked up and the catheter was passed down almost entirely into the duodenum through the distal portion. Inasmuch as there had never been any dilatation of the common duct, it was not feasible to insert upwards the funnel end of the catheter, so the funnel was amputated, and the cut end passed up to the liver. In order to anchor it in place, a medium sized wax silk ligature was tied to the catheter at the area uncovered by the duct and anchored to the surface of the skin by adhesive plaster; then the ends of the ducts were approximated toward one another to within half an inch. The wound was sutured. Some bile discharged until the anchor thread was cut four and one-half months after operation, September 14th. The catheter passed November 7, 1921. The wound ceased leaking in ten days after the thread was cut. The patient was then apparently perfectly well. See X-ray chart of catheter *in situ*.

Case VI.—O. E. C., age sixty-seven, white, married, male. Onset two weeks ago, weakness, anorexia, heaviness in stomach, nausea, emesis. Jaundice began two days later and grown steadily deeper, with clay-colored stools. Past history negative. Entered hospital, February 17, 1923. Temperature ranging up to 101.6; pulse 100; respiration 24. Blood count: reds 4,450,000; white 18,400; hæmoglobin 95 per cent. Urine, loaded with bile, otherwise negative. Stools acholic. Physical examination, general abdominal rigidity.

Operated February, 19, 1923. Massive adhesion about gall-bladder, which was found to be very small, thickened, filled with small stones and muco-purulent material, and no bile. Lining ulcerated. Gall-bladder removed. Cystic end ligated. Common duct greatly distended to such a size, it was at first mistaken for duodenum. A large stone found wedged in ampulla of Vater—removed through slit in common duct. A small No. 14 Fr. catheter was fed downward through this slit into duodenum, all but last two inches which was fed upward with its bell-mouth towards the liver in the common duct. A heavy silk anchor line tied to catheter at point opposite slit in common duct, was carried out and fixed to skin by adhesive. Slit completely sutured around anchor line. Abdomen closed with accessory Bullitt drain for two days.

Patient made uneventful recovery; jaundice rapidly disappeared; never any discharge of bile dressings. X-ray picture of March 15, 1923 (slide No. 6) shows catheter still in place. Anchor line cut March 15th. Patient last heard from June 1st: feels entirely well and is attending to business; is not sure whether he has passed catheter or not. Advised to have X-ray picture taken to prove this.

Case VII.—J. L., age fifty, male, white, married. Present complaint, intermittent jaundice, alternating with intermittent biliary fistula, following an operation done elsewhere one year ago for relief of typical gall-stone history of three years duration. History otherwise negative. Entered St. Luke's Hospital, February 5, 1923. Examination shows small discharging biliary fistula in an otherwise healed right rectus scar. Blood and urine normal. Stool negative. A diagnosis was made of common duct stone from history and especially from an X-ray picture

taken during the course of a barium gastrointestinal examination, which left stone plainly coated with the barium (see Slide No. 7), which had regurgitated into ampulla and remained behind when the duodenum had emptied itself.

Operated February 7, 1923. Fistula traced down through adhesions to remains of a badly diseased gall-bladder, which was removed. A large stone easily palpable in the ampulla of Vater could not be milked back into the common duct. A transduodenal choledochotomy allowed removal of stone. Then a fine catheter was fed through stump of cystic duct, through the common duct into the duodenum: the other end of catheter brought out to the skin. Fenestra had first been cut in side of catheter in that portion contained in common duct. The hole in the duodenum was then completely closed with a double row of silk stitches. Abdomen closed with accessory Bullitt drain. Patient made uneventful convalescence. Catheter removed at the end of a week. Patient last seen June 4th; feels fine; has gained twenty-five pounds; back at work.

A QUESTION OF SIZE*

By William J. Mayo, M.D.
of Rochester, Minn.

When Brown, the English botanist, began the observations on physics which culminated in his written communications of 1827, he focused attention on a subject of enormous importance. The questions he raised a century ago are to-day perhaps the most important of all those before the scientific world. Brown noted, as man undoubtedly had noted from time immemorial, that when a pencil of bright light was thrown into a dark room, there were to be seen in the air certain rapidly moving particles of which there was no other physical evidence. On experimentation he found these dancing motes under conditions in which freedom from air disturbance of any kind had been obtained, and he further noted with the microscope the continual movement among minute particles suspended in a liquid. Because of his investigations the peculiar vibratory motions of these particles were called Brownian movements. The great physicist, Dalton, was at this period working on the atomic theory and the constitution of the molecule, and in connection with his investigations the so-called Brownian movements were even more happily designated "the dance of the molecules." The most important contribution to a proper understanding of these phenomena was that of Thomas Graham, Master of the Mint in London, who in 1861 published his painstaking observations which led to the first great description of colloid bodies. Graham's work was largely based on dialyses of colloid-sized substances through parchment paper. Tyndall called attention to the curious phenomenon occurring in the track of a luminous beam (called the Tyndall phenomenon), the colorings of which are the effect of sunlight on colloids in the air, and investigated the transparency and opacity of gases and vapors under radiant heat.

To those who have given little thought to the term *colloid*, especially as it is used in medicine, the word appears to have some special meaning over and beyond that of size, but as a matter of fact, colloid refers only to size. Dividing matter into three great groups, there are first, those objects which can be seen directly with the eye, or with the eye aided by the microscope. The best microscope has a magnification which will reveal objects of 1/10 micron in diameter. Second, at the other extreme, there are the atom, the molecule, and the electron, which cannot be seen. Third, those particles of matter lying between the two extremes in size (1/10 of a micron or 1/250,000 of an inch, and 1/1000 of a micron or 1/25,000,000 of an inch) are called colloids. In this third or colloid group, the particles are too small to be seen directly, but the colloid-sized particles are large enough to scatter a ray of light and they therefore refract the light ray. The atom, the molecule, and the electron are too small to scatter the light ray and therefore do not

* Read before the American Surgical Association, June, 1923.

refract it, although under experimental X-ray conditions the nucleus of the atom was demonstrated by Thompson and Ashton. Definite relationships can be shown, as evidenced in 1913, by the remarkable work of Henry Moseley, a young Englishman, whose death in the Gallipoli campaign was one of the irreparable losses of the Great War. Moseley analyzed the atom by the reflection of X-rays and showed that there were ninety-two possible elements between hydrogen, the lightest, and uranium, the heaviest, all but four of which are now known.

The ultramicroscope which is used to catch the reflection of the colloid bodies gives no idea of the shape or the composition of the object itself, but by serving as a mirror and reflecting the light shows that such a body is actually present. The shortest ray of electro-magnetic vibration is the gamma ray from radium, 1/1,000,000,000 of an inch. The next is the X-ray, which is about 1/100,000,000 of an inch. It was with this extremely short X-ray that Moseley did his work. The wave length of the X-ray, which in this connection amounts to the same thing as size, is 1/50,000 as great as the yellow light ray from the sun, and it is to this property that the X-ray owes its great penetrating power. The shortest light ray visible to the eye is approximately 1/30,000 of an inch in length. The longest waves, hertzian, are the so-called wireless, which are from one-half mile to four or five miles in length, and experimentally have reached the length of 1200 miles or more.

A most remarkable fact is that colloids, atoms, molecules, and electrons are not greatly affected by gravity and remain in rapid motion more or less permanently suspended in their medium, although all are affected by pressure, temperature and atmospheric conditions. The evaporation of water is an illustration of this property. Water exists in the atmosphere, but under certain conditions does not greatly feel the pull of gravity. Under specific atmospheric conditions, however, as when the evaporated water rises to a height where the air is rarefied and by greater coldness than exists at the point of evaporation, it gathers together in colloid form as clouds. For rainfall of an inch and a half to an acre, 144 tons of colloid water practically unresponsive to the pull of gravity are suspended over each acre; if the change from a dispersed to a fluid state takes place rapidly, the electrical energy on the surface of the colloidal particles is given off as an electrical disturbance, thunder and lightning.

Gortner and his pupils may influence the feeding of the world by their discoveries of the importance to plants, of water in a bound form, and their demonstration that the effect of freezing and dryness on plant life depends on whether the water contained by the plant existed in a free form or a bound form. The difficulties which stood in the way of finding food plants which would withstand winter killing were enormous. Years of patient waiting were often necessary before weather conditions existed to make the demonstrations possible. When Gortner conceived the idea that water might exist in a bound state uninfluenced by ordinary conditions, atmospheric or thermic, he found that if plants which did not winter kill were pressed in a hydraulic

press, little or no juice was obtained, and that the amount of juice that could be expressed was directly related to the ability of the plant to withstand frost. He found that those plants which would not winter kill contained little unbound water, that is, water in a free form, while those that were destroyed by freezing contained relatively a large amount of free water. Carrying his experiments out in the desert, he found conditions comparable to drought; plants that could withstand dryness contained water, as did other plants, but in a bound form. Experiments in the compression of water, which is one of the most incompressible of all substances, have shown that the water in a film on colloid surfaces can be compressed to 75 per cent. of its volume, and that under such conditions it behaves as a solid and does not evaporate at 300° C. in a complete vacuum.

We know that a substance in solution, common salt, for instance, exists, although it can no longer be seen; when the water is evaporated the salt is again in evidence. If a pencil of light is thrown through such a solution it will not be diffused, showing that the light rays have not met bodies in the solution which are larger than the ray of light, and consequently the light is not reflected. It was Arrhenius, the Swedish scientist, who defined the electrolytic theory of solution, asserting that salts separate in water into positive and negative parts, and that such solutions are ionic. An ion is an unsatisfied electric charge. A chemical reaction is always accompanied by an exchange of electric charges between elements; the ion carries a definite charge and moves with the electric current. Colloids, atoms, and molecules may give off electrical energy under certain conditions.

One may well ask, Where does the energy contained in the atom, molecule, and colloid reside? The Nobel Prize in Physics for 1922 was given Dr. Niels Bohr of Copenhagen, who about ten years ago revealed his conception of the atomic system as a solar system in which the sun is represented by a nucleus of positive electricity and the planets by rapidly revolving negative electrons, and on this theory he calculated the wave lengths of light in each line of the spectrum. The positive core of the atom is exceedingly dense and heavy compared with the electron, in which the activity of negative electricity resides. The positive core might be said to be the electric centre of gravity toward which the negative electrons constantly are pulled. Knowledge of electrical energy is largely based on an understanding of the negative electron which is only 1/1800 the density or weight of the positive hydrogen nucleus which is the smallest and lightest of known atoms of matter. It is because of its extremely small size and weight that the negative electron can move with such extraordinary rapidity through solid substances, especially copper and other electrical conductors.

The force that exists in the atom and molecule is inconceivable. Rutherford, the great physicist, says that he looks forward to the day in which energy for all our uses will be atomic. One of the scientists associated with the General Electric Company says that there is sufficient energy in a teaspoonful of water to drive the largest battleship across the ocean. The electric

power in the molecule depends on the mass of the nucleus, that is the number of positive charges in the mass, and the number of negative electrons circulating around the positive nucleus, the charges in the more stable compounds going up in arithmetical progression of four, the octet being the most stable.

Most of the biochemical reactions in the body depend on physical states. Krogh, whose experimental studies of the blood capillaries won for him the Nobel prize in physiology in 1920, has added greatly to our knowledge of the mechanism of body nutrition. It had been believed that the capillaries were endothelial channels in the tissues, but Krogh has confirmed the observation that even the finest capillaries contain smooth muscle fibres through the walls of which oxygen and crystalloids, such as glucose, salts, and the amino acids, supply the body cells by diffusion. Diffusion depends on pressure. Crystalloids are in a molecular state and penetrate the capillary walls everywhere, because the pressure inside the arterial capillary is greater than that in the tissue space, and greater in the tissue spaces than in the venous capillary which receives the waste products of oxidation. Unless there is great dilatation of the capillaries, which increases their permeability to larger bodies, the colloids normally do not penetrate the capillary walls, except in the liver and gastro-intestinal tract. Histamin dilates the capillary wall so that its interspaces permit the escape of larger-sized particles such as colloids, and as in shock the experimental animal bleeds to death in its own tissues. The colloids of the blood are of different sizes; hence, there is variation in the permeability of the capillary wall to different colloids. The osmotic pressure, the state of dilatation of capillaries, and the size of the colloid molecule are the controlling factors. Increased work of any organ of the body causes dilatation of the capillaries. This power of dilatation and contraction lies in the non-striated muscle coat of the capillary. Variations in calibre of the capillaries may be brought about by the many influences which affect life processes and are to a great extent independent of nerve control. For instance, the effect of cold on the skin is to produce contraction of the arterial capillaries, resulting in blanching, which is followed by blueness due to dilatation and stasis of the venous capillaries distended with non-oxygenated blood. One can conceive that many substances said to be poisonous are poisonous because of their physical condition; certain tissue filters may become plugged by particles which of themselves are not poisonous in the chemical sense, but are attracted to certain localities and plug the normal interspaces, suspending internal respiration.

The point should be emphasized that normally the blood capillaries pick up only molecular substances or extremely fine subdivisions, soluble in water. Generally speaking, it is the function of the lymphatics as absorbents to pick up material substances insoluble in water, such as bacteria, protozoa, and the cancer cell, which are too large to enter the blood capillaries. This absorption is through the agency of phagocytes which by diapedesis reach the lymphatics. The reactions in the lymph-nodes represent the struggle of the gland to detoxicate these pathologic agents. The lymphatic channels lead from one

gland to another, but in each gland they break up into lymphatic capillaries, varying from a micron to 1 mm. and into endothelium-lined pockets and sinusoids before they are gathered again into the larger lymphatic channels for onward movement. These physical facts are of the greatest importance in relation to the infections which spread by way of the lymphatic system, such as tuberculosis, syphilis and cancer.

Bacteria are electronegative, but the bacterial spore carries a positive charge. Evidence goes to show that endothelial cells which are phagocytes are electropositive. This research is incomplete, however, as an entire series of cells has not been worked out.

An idea of the minuteness of the constituents of a cell is gained from the following estimated analysis. A cell is composed of (1) protein, which is always colloid; (2) carbohydrates, which may be either crystalloid or colloid; (3) lipoids or fats, which are either colloids or emulsions; (4) salts, which are crystalloid, and (5) water, some part of which, large or small, depending on the physiological state of the cell, may be in colloidal form. As a specific instance, the composition of a liver cell, expressed in molecules, is estimated to be: protein, 53,000,000,000; fats and lipoids, 166,000,000,000; salts and other crystalloids, 2,900,000,000,000, and water 225,000,000,000,000.

Perkin, working in the Royal College of London, discovered the dyes which Hofmann took back to Germany and which were the basic discoveries that gave rise to the explosives exploited in the World War. Abel and Rowntree in 1909, and Rowntree and Geraghty in 1910, in working on the elimination of aniline dyes from the kidney, were led to the discovery of phenolsulphonephthalein as an index to renal function. Evans has shown that dye elimination is purely a question of physics, that is, of the size of the dye particle which is permitted to pass the kidney filter. Bowman, for whom Bowman's capsule was named in 1842, made the first of that long line of studies on the malpighian bodies in relation to the system of tubules of the kidney, work continued later by Ludwig, Cushny, Marshall, Richards, Drinker, and others, which suggested that the essential action of the kidney was that of a filter. Sollman, seventeen years ago, in his perfusion experiments found that the kidney of an animal removed from the body could be made to filter urine. Cushny by his pharmacological investigations of the elimination of drugs from the kidney developed most important data as to kidney filtration. While it is true that urea is excreted in small amounts in the saliva, through the skin, the mucous membranes of the intestine, and so forth, the natural urea filter is the kidney. In this connection it is most interesting to note that urea is one of the smallest of the molecules, being but slightly above atomic size, and that it is non-hydrophilic, that is, it does not absorb water. For this reason it is one of the most diffusible molecules and passes with great rapidity in and out of the tissues of the body. While urea is non-hydrophilic, its elimination through the kidney is closely associated with the water balance. Reduced area output is accompanied by a corresponding

increase of the watery constituents of the urine if a fair degree of renal function is maintained.

Sir William Crookes, who died in 1919, was the last of the great all-around physicists. Physics has grown so tremendously that each physicist of to-day can claim to have accurate knowledge of only a small part of the subject. Crookes, in his attempts to demonstrate the fourth state of matter, exhausted the air from a heavy glass bulb. When certain electric attachments were made, the bulb became filled with luminous matter, and, as Crookes expressed it, "actually touched the border land where matter and force seem to merge into one another." He named this luminous substance the cathode ray, which was later shown to be composed of negative electrons, which is the fundamental conception of the X-ray. He pointed out also that when X-rays come in contact with solid matter they give rise to shadows, and that the cathode rays, when outside a magnetic field, always travel in a straight line. Röntgen was working with the Crookes' tubes when he discovered the X-rays. The use of energy in the form of rays such as radium, X-ray, and so forth, are examples of biophysics in relation to medicine. Bayliss, speaking of chemistry and physics, says that "The boundaries between these two branches of science are rapidly becoming obliterated."

When we survey the modern field of research which goes under the general title of biophysics, the commercial inventions and developments that concern physics in the sciences and arts, we get some idea of the importance of this work which has been neglected in its relation to medicine. Problems worked out in connection with industry, agriculture and animal husbandry have raised scarcely a ripple in medicine. Perhaps we have been subject unconsciously to the theologic opinions which have recently been so broadly emphasized by a world-known orator who believes that man was created independently, and not through evolution of preëxisting species, a view more flattering to our vanity than to our intelligence. One cannot help, however, but sympathize with his recent vehement defense of the ape, as not responsible for man.

Perhaps enough has been said to further the plea that biophysics be given a more important place in the medical school curriculum, and that some of the time of the overburdened students of medicine now occupied by chemistry be given to medical biophysics.

SURGERY OF THE THYROID AND ITS MORTALITY*

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and

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During the last sixteen months, to May 1, 1923, 2524 operations were performed on 1949 patients with goiter. Twenty-five died, a mortality by operation of 0.99 per cent., and by case of 1.28 per cent. Unless accurately classified according to the presence or absence of hyperthyroidism, these percentages have no special significance, for an adequate appreciation of the mortality from surgery of the thyroid gland is dependent on the understanding of the operative dangers incident to the various types of goiter.

According to the dangers attending surgery, all lesions of the thyroid may be classified into two groups: goiters unassociated with hyperthyroidism, and goiters associated with hyperthyroidism. The operative risks in the two groups are not comparable. In the former, the dangers are confined to the accidental causes to which any operation of equal magnitude is subject, while in the latter the greatest danger lies in the disease itself, or the residual effects of the disease. For instance, the technically successful operation may precipitate or be followed by an acute exacerbation of hyperthyroidism, from which the patient does not recover. It is obvious, then, that the mortality rate in "goiter surgery" is decidedly influenced by the proportion of goiters without hyperthyroidism included in the computation.

The goiters unassociated with hyperthyroidism, and which are amenable to operation, include adenomatous goiters, malignant goiters, thyroiditis, and occasionally the colloid goiter. As the health of the patient is unaffected by the goiter, the dangers involved in its removal are limited to operative and post-operative accidents, which include hemorrhage, pulmonary infections, obstructive dyspnœa, tetany, air embolism, pulmonary embolism, infections, and intercurrent diseases.

With the development of the standardized operation, and care in the details of operation, technical errors have been reduced to a minimum. In the Clinic, the incidence of post-operative obstructive dyspnœa and pneumonia have been materially decreased since it has been appreciated that both are at least

* Read before the American Surgical Association, June, 1923.

partially avoidable. In the past the causes of post-operative obstructive dyspnœa were believed to be confined to collapse of the trachea and œdema of the glottis, both unavoidable complications, but in recent years a clearer recognition of the important part played by the injury of the recurrent laryngeal nerve, has led the surgeon to exercise more care in its avoidance; in consequence, post-operative obstructive dyspnœa has been practically eliminated as a danger in goiter operations. Likewise the incidence of post-operative pulmonary infections has been materially reduced by the avoidance of prolonged anæsthesia, and of injury to the recurrent laryngeal nerve.

Intercurrent diseases, such as diabetes, influenza and thrombosis, are unavoidable complications, but must be considered if, as is the practice in the Clinic, the mortality rate is to be computed from all patients who die in the hospital without regard to the cause of death or the length of time after operation.

In the last sixteen months 819 thyroidectomies were performed on 819 patients. Three patients died, a mortality of 0.36 per cent.

The goiters associated with hyperthyroidism include exophthalmic goiter and adenomatous goiter with hyperthyroidism. The development of acute hyperthyroidism, and the presence of visceral degenerative changes, comprise the added dangers to surgery in both types, but as the relative importance of these dangers varies in the two types, and as pre-operative measures are not comparable in efficiency, it is desirable to discuss the surgical problems of the two diseases separately.

Exophthalmic Goiter.—Visceral degeneration in patients with exophthalmic goiter, due to the long continued hyperthyroidism, was formerly the most important cause of the high operative mortality. But in recent years, owing to the wider dissemination of the benefits derived from surgery, a larger proportion of patients with exophthalmic goiter are coming to surgery earlier in the course of the disease, and before the development of visceral changes. This is illustrated in a forceful manner by a comparison of the data for different periods, relative to the duration of hyperthyroidism. In 1909, the average duration of hyperthyroidism in the series of patients with exophthalmic goiter was thirty-one months; in 1916, twenty-three months, and for the first six months of 1922, nineteen months. This fact has influenced not only the reduction of the operative mortality, but the improvement in the end results.

Our means of combating the post-operative reaction of hyperthyroidism or dysthyroidism when once induced, are ineffectual. The mode of attack lies rather in prevention. Through the coöperative efforts of the internist, the laboratory workers, and the surgeon, great improvement in the pre-operative preparation of these patients has been accomplished, so that to-day the occurrence of post-operative reactions has been reduced to a minimum.

The pre-operative preparation consists of medical and surgical measures. About 30 per cent. of the patients, on admission to the Clinic, have only a mild degree of hyperthyroidism, and as their general health is unimpaired, preliminary treatment other than routine preparation is unnecessary. Preliminary treatment is indicated in the other 70 per cent. of patients on account of the intensity of the hyperthyroidism, or the patient's debilitated condition. At first, until sufficient data was acquired, preliminary treatment was carried out in the hospital in all instances, but gradually it has become possible to make selections, so that now patients with mild hyperthyroidism are prepared outside the hospital. The medical measures employed for patients with severe forms of the disease consist of rest, adequate food and fluid intake, digitalis as indicated, and the oral administration of iodine (Lugol's solution). By repeated basal metabolic estimations at intervals of three to four days, the progress of the disease can be accurately watched. Improvement in the condition of the patients is usually apparent in from ten to fourteen days, and a large number of these become safe risks for primary thyroidectomy. If doubt still exists as to operative risk, a preliminary surgical procedure, such as injection of hot water, or a ligation, is indicated as a tolerance test. A further number of the patients, who show no reaction to these procedures, are judged good risks, and the operation is then completed. Because of extreme loss of weight or strength, or because of the presence of marked visceral degenerative changes, in a small percentage (20 to 25 per cent.) of the total number of patients with exophthalmic goiter, two ligations and a three months' period of rest are indicated.

The lowered operative mortality alone has fully justified the employment of the combined medical and surgical management of patients with exophthalmic goiter. Thus, during the last sixteen months ending May 1, there were 1398 operations on 853 patients with exophthalmic goiter. Thirteen died, a mortality by operation of 0.92 per cent., and by case of 1.5 per cent.

A comparison of the operative procedures employed in the first four months of 1923, with those of the same period for the five preceding years, is interesting. Primary thyroidectomy was performed in 56 per cent. of the patients in 1923, while the average for the five preceding years was only 38 per cent. Twenty-four per cent. of patients had two or more ligations before thyroidectomy in 1923, and the average for the five preceding years was 37 per cent. Expressed differently, under the combined medical and surgical management, primary thyroidectomy has increased 18 per cent., and the necessity for two or more ligations has been reduced 12 per cent.

Adenomatous Goiter with Hyperthyroidism.—The added dangers of surgery in this type of case are also due to the possibility of the development of acute hyperthyroidism, and to the presence of visceral degenerative changes. Owing to the usual mild intensity of hyperthyroidism, the possibility of an exacerbation of severe acute hyperthyroidism is of relatively

small significance, while the presence of visceral degenerative changes is the most influential factor in the mortality rate. In this respect adenomatous goiter with hyperthyroidism differs from exophthalmic goiter. In cases of exophthalmic goiter, the symptoms may begin gradually or abruptly, prior to, coincident with, or shortly after the appearance of the goiter; thus the patient realizes early that he is not well, and seeks relief soon after the onset. But in cases of adenomatous goiter with hyperthyroidism, the patient has had a goiter without symptoms for many years, and the onset of hyperthyroidism is so insidious that the disease often progresses to a stage of visceral degeneration before he realizes any change in his condition, and operation is accordingly delayed. Because of this and because of the fact that preparatory measures are inadequate, the operative risk is relatively high.

During the past sixteen months there were 277 patients with adenomatous goiter with hyperthyroidism operated on. Nine patients died, a mortality of 3.24 per cent. It is obvious, therefore, that the mortality rate is dependent more on the number of bad risk patients accepted for operation, than on any factor in the operative or pre-operative management. Because of the facts that the successful removal of the adenomatous tissue is followed in from ten to fourteen days by the complete subsidence of hyperthyroidism, and that the improvement is immediate in many of the otherwise hopeless cases, extension of the limits of operability to include nearly all patients is justified.

CONCLUSIONS

1. In order to evaluate accurately statistics on the results of operations on patients with goiter, the knowledge of two facts is essential, the proportion of goiters without hyperthyroidism included in the computation, and the basis on which operative mortality is reckoned.

2. The operative risk in cases of goiter without hyperthyroidism cannot be compared with that of goiter with hyperthyroidism; in the former the dangers are confined to the operative and post-operative accidents; in the latter the greatest danger lies in the disease itself.

3. The reduction of the mortality to 1 per cent. in surgery of exophthalmic goiter is attributable to three factors: (a) patients with exophthalmic goiter are coming to operation earlier in the course of the disease, before the development of visceral degenerative changes, (b) by the combined medical and surgical management, the development of post-operative acute hyperthyroidism has been reduced to a minimum, and (c) a clearer recognition of the dangers involved in the injury of the recurrent laryngeal nerve has led the surgeon to greater care in its avoidance.

4. The combined medical and surgical management of patients with exophthalmic goiter is warranted from the economic standpoint, as it has reduced the necessity for ligations.

5. As preliminary measures are ineffectual in adenomatous goiter with hyperthyroidism, the mortality rate is dependent on the number of bad risk patients accepted for operation.

Report of Cases of Goiter, January 1, 1922 to May 1, 1923

	Cases	Mortality	Per cent.
Thyroidectomies for exophthalmic goiter*	703	6	0.85
Ligations preliminary to thyroidectomy for exophthalmic goiter	591	5	0.84
Hot water injections preliminary to thyroidectomy for exophthalmic goiter	101	1	0.99
Injections 0.5 novocain preliminary to thyroidectomy for exophthalmic goiter	3	1	33.33

*The thyroidectomies were complete operations in one stage, except in two instances, in which the technical difficulties made it advisable to divide the operation into two stages.

THE MANY-STAGE OPERATION FOR GOITRE*

By Martin B. Tinker, M.D.
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The management of toxic goitre is still one of our difficult problems, after over twenty years intensive study by many active workers. There is fairly general agreement that surgery offers the most reliable treatment, after extended trial of serums, endocrines, radium, X-ray, and a host of other measures. There is also quite general agreement as to the value of dividing the operation into stages, but there are still some fatalities from failure to recognize the gravity of conditions calling for the many-stage operation, or the time when even the least intervention can be safely undertaken. Judgment how much to do, and when to do it, still makes the difference between life and death, health or invalidism, in this as in many other fields of surgery.

In a paper entitled "Factors Influencing the Safety of Operation for Goitre" read at the Surgical Section of American Medical Association meeting at Los Angeles, June, 1911, I advocated preliminary study and treatment of from a week to a month, followed by operation in stages, in the management of doubtful cases. Two types of operation were suggested: first, that beginning with elevation of the flap as for excision, and interrupting the operation and packing the wound at any stage when the patient's condition suggested that it may be unsafe to continue much farther. Second, the ligation of one or more important vessels supplying the thyroid gland, as advocated by Kocher, to be followed, as the patient's condition warranted, by further ligation or excision, or possibly by further ligations and repeated partial excisions. These methods still have their place, but further experience has suggested modifications of value, both as concerns safety and permanent results. The most important advantages of these procedures are: (*a*) first of all, greater safety to life; (*b*) the possibility of earlier intervention, thus arresting toxæmia before serious permanent damage results to vital organs; (*c*) extending the range of operability by a relatively trivial and safe procedure, making many desperately ill patients fit risks for later curative surgery. The disadvantages are: slight to considerable extra scarring; added hospitalization and expense; and, as concerns wound packing in many-stage excision, a slight but none the less definite risk of infection. I have never seen infection of any gravity, but where the patient's serious condition seemed to make it safer to delay closure for several days, occasionally there has been low-grade infection, causing delay in healing and some additional scarring.

The chief advantage of ligation is that, by a relatively simple and safe procedure, taking but a few minutes time, approximately one-fourth of the blood supply is cut off, theoretically at least, and the activity of the gland

* Read before the American Surgical Association, June 1, 1923.

reduced to that degree. In actual practice, the reduction in gland activity does not always follow, partly because the collateral branches are so numerous and widely distributed that the blood supply is rapidly reëstablished. The number of vessels at the upper pole of the thyroid which we have encountered at the operating table, not usually shown in anatomical reference books, has been so great that my associates and I started several years ago to record them. From a study of two hundred consecutive ligations we found that the text-book descriptions of the superior thyroid artery dividing into main anterior and posterior branches is most unusual; that two or three groups of vessels is common; as many as seven vessels were found in one case; and in another the largest and most active vessel came along the isthmus from the opposite side. One of the earlier editions of Quain is the only text giving any adequate description of the numerous and irregular sources of blood supply to the superior thyroid pole, which we have found the common rather than the abnormal distribution. It is evident that in order effectually to cut off the blood supply of the superior thyroid pole, and get the supposed advantage of ligation, there must be fairly free exposure and the entire blood supply secured. Such increased care to secure all the vessels of the superior thyroid pole has not, in my experience, greatly increased the time required for ligation, and has not added appreciably to the risk of operation. Lobes removed at later partial thyroidectomy, in a considerable proportion of cases, show clearly the effect of complete cutting off of the blood supply, both microscopically and frequently in the gross. In certain cases there is apparent increase of fibrous tissue with lessened gland cells. In other cases the part of the gland, originally hyperplastic, influenced by ligation, takes on the appearance of simple colloid goitre. With widely differing blood supply, there are of course widely differing results following ligation.

Another important advantage of the many-stage operation, with multiple ligations, is the time required. Certain of these patients will die, whatever is done, or if nothing is done; but the majority will recover if sufficient time is taken for rest and preliminary treatment. Goodpasture has shown that there are definite and serious myocardial changes, apparently the result of extreme thyroid toxæmia, and it would be unreasonable to expect a heart crippled by myocarditis or dilatation to recover without prolonged rest. The same is doubtless true of damage to the nervous system. The X-ray, which is in great favor in the treatment of such cases in certain localities, has seriously aggravated the symptoms in a number of patients who have come under my observation. These patients have later responded well to prolonged preliminary rest and care, followed by ligations, and later, partial excision. If a year or even more, devoted to preliminary treatment and modified rest cure, between the various operative stages, will bring such a patient back to reasonable health and efficiency, it seems a small price to pay out of the twenty-five to forty years normal expectation of life which many of these patients have. Of course so long a time is unnecessary except in extreme cases. The time element gives such treatment by ligations and later

excisions, decided advantages over many-stage excision in such cases; for even if the patient survives excision, extensive operation in the stage of extreme toxæmia, undoubtedly puts a strain on the heart from which it may never fully recover, after ever-so-prolonged post-operative rest. The considerable number of articles on many-stage excision which have appeared during the past two or three years, lead me to believe that it is being used in some of the cases of extreme toxæmia, in which preliminary ligation, preceded and followed by prolonged and modified rest-cure, and later followed by partial excision, would give better permanent results. Having originally advocated this method and used it in suitable cases ever since, I feel justified in criticising its use in cases in which I feel strongly that the more conservative plan would give better permanent results.

Ligation at the lower instead of the upper pole of the thyroid, I have not used as a part of the many-stage operation, because of (1) risk of injury to the recurrent nerve; (2) greater difficulty, especially with deeply located, especially intrathoracic or substernal growths, or if there were many extra vessels, as has proved so common at the upper pole; (3) the formation of deep adhesions, making difficult a subsequent partial thyroidectomy, not a fanciful difficulty as I have discovered in operating upon patients whose lower pole vessels had been ligated elsewhere.

Ligation of all the main thyroid vessels I have also not employed, because, as shown many years ago by the fundamental experimental studies of my former chief, Dr. William S. Halsted, at least one pole of the thyroid must be left with unimpaired blood supply if normal function is to be maintained.

In this connection it may not be out of place to mention two little-used criteria in estimating the fitness of extremely toxic patients for any surgery; the differential blood count, and the pulse deficit chart. These we have found of sufficient value so that we record them along with basal metabolism and pulse rate. Cabot mentioned the association of lymphocytosis with exophthalmic goitre, in an early edition of his book on the blood; and Kocher considered the blood examination of considerable value. While not of as much value as some other data, the blood report helps to make up the complete clinical picture, from which we decide what it is best to do or leave undone, and ordinarily it checks up in fair accord with the other clinical tests. A pulse deficit chart, or some other means of regularly recording the relation of the apex beat to the pulse, seems to me of far greater value. Any persistent discrepancy between the apex beat and the radial pulse in a patient who has had fairly prolonged rest, with digitalization and other preliminary treatment, we have considered sufficient evidence of myocardial insufficiency to make even the least of the many-stage procedures too hazardous in practically all cases. To be of value, the record should be made by a specially instructed and intelligent nurse, or by a doctor. Many untrained pupil nurses do not use a stethoscope well enough to record the heart accurately. When accurately charted, it gives at a glance, knowledge

of first importance. Fortunately the heart condition, and deficit-chart which records it, improve, in the majority of cases, under suitable preliminary rest and care.

In conclusion, to emphasize a few points in this brief paper which seem to me important: operation divided into many independent stages not only makes it possible to save the lives of most of these desperately ill patients, but with the many-stage operation, it is easier to enforce the rest and care indispensable to ultimate complete recovery, especially in those cases with dilated hearts and myocardial degeneration.

The disadvantages of greater scarring, prolonged hospitalization, and increased expense, seem trivial when safety and permanent recovery are considered.

The advantages of preliminary ligation will be more fully realized when the pole of the gland is well exposed, so as to make certain the securing of all vessels, great and small, main and collateral.

Many-stage excision with wound packing is best reserved for the few cases in which it has proved impossible by careful preliminary study correctly to estimate the gravity of the patient's condition, and unexpected grave symptoms develop during operation. In such cases it saves life, and the disadvantages of slight risk of infection and additional scarring scarcely deserve consideration.

EVENTRATION OF THE DIAPHRAGM*

By Malvern B. Clopton, M.D.
of St. Louis, Mo.

I present two cases of a rare anatomical anomaly that offered interesting problems in diagnosis, that in one instance led to an operation that we believe was uncalled for, and in the other instance made us hesitate to operate because of the anomaly, and spared the child an unnecessary operation. Both children present the same findings. There is a high lying diaphragm on the left side, with the stomach, spleen and large bowel occupying the space usually filled by the lung. The heart is in the right chest. The stomach is large. The large bowel is also dilated and enlarged. The liver is vertical and right-sided. The chest wall shows a slight bulging of the lower half of the left side. This condition was designated as eventration of the diaphragm by Cruveilhier.

The first case, E. K., St. L. Ch. H., No. 16368, December 30, 1920, had been operated six months before admission to the hospital, at the age of fourteen months, when a part of the eighth rib on the left side was resected and a tube introduced. At that time the child had had influenza and bronchopneumonia followed by what was considered to be empyema. The drain had remained in place six months, and a week after it was removed an abscess formed along the tract forward of the fifth rib. At this time the child was brought to the hospital because the fever had been high, the thirst violent, and it had vomited everything for three days. The baby cried continuously for water, which it drank ravenously, only to vomit it immediately. The child's condition was pitiful. It was wasted, extremely restless, temperature elevated. Water was given by rectum and sodium bicarbonate and glucose intravenously and saline intraperitoneally. After twenty-four hours the anhydræmia was relieved, and feeding was started through an in-lying duodenal tube. The sinus through the resected rib led into a small cavity, which was an extra-pleural abscess, and outside the fifth rib there was another abscess of the chest wall which extended forward. Except for noting that the heart was displaced to the right, the physical examination of the chest was unsatisfactory. The X-ray showed what we thought was a diaphragmatic hernia with part of the stomach in the chest. There was no obstruction to the œsophagus. A clear gas-filled area was seen bounded above by a clean-cut curved line and below by a horizontal fluid level. On shifting the child's body the fluid flowed into the clear space in the chest, so that when the patient was inverted the chest was filled with fluid, except for a small area above the rounded dome of the stomach which was occupied by the lung. The stomach was apparently divided into two compartments.

At first we thought that at the time the operation was performed for supposed empyema, six months before, the diaphragm had been opened near the costal attachments and the stomach had worked its way through. This opinion was later revised when we fortunately got the plate taken before the first operation, which shows the small lung space on the left, and lying beneath the intact diaphragm, a clear gas-filled space which evidently represents the stomach just

* Read before the American Surgical Association, June 1, 1923.

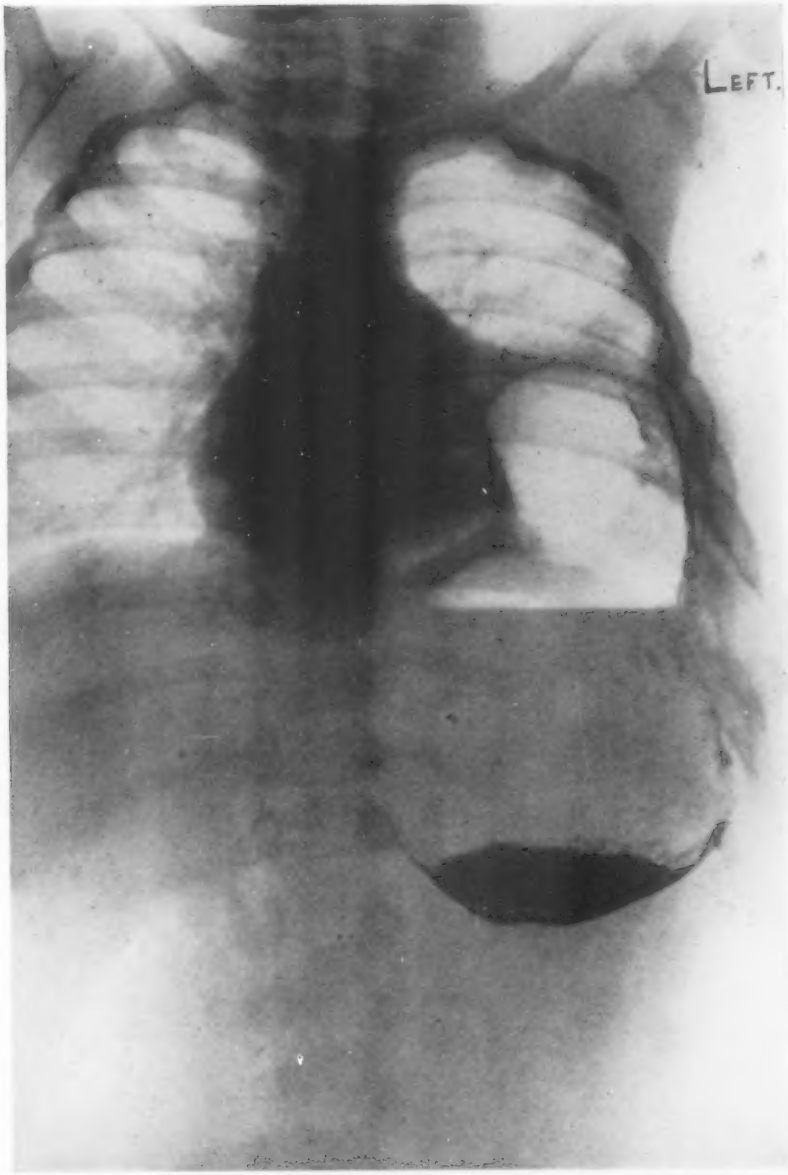

FIG. 1.—Case I. At time of admission. Eventration of diaphragm which we thought to be a hernia. Valve-like projection from the median shadow of the stomach, which simulated the diaphragm. Case had been operated six months before for supposed empyema. Note right-sided position of the heart.

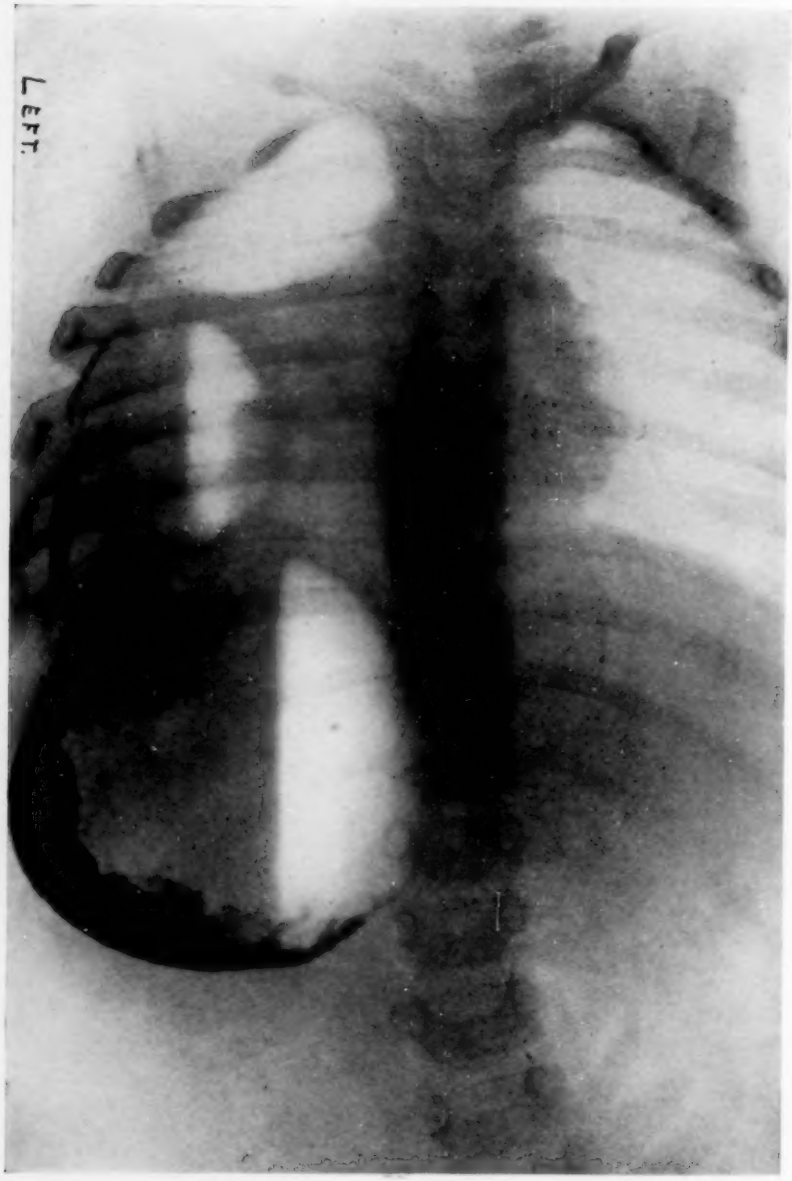

FIG. 2.—Case I. Taken with child on the side. Different levels of fluid in stomach due to air trapped in upper compartment by valve-like projection of stomach wall. Such a condition as might be seen in hernia, but intact diaphragm is seen above top of upper end of stomach.

FIG. 3.—Case I. Two years after Figs. 1 and 2. Child inverted. Bismuth in stomach shows outline of intact diaphragm, valve-like projection in stomach wall has disappeared.

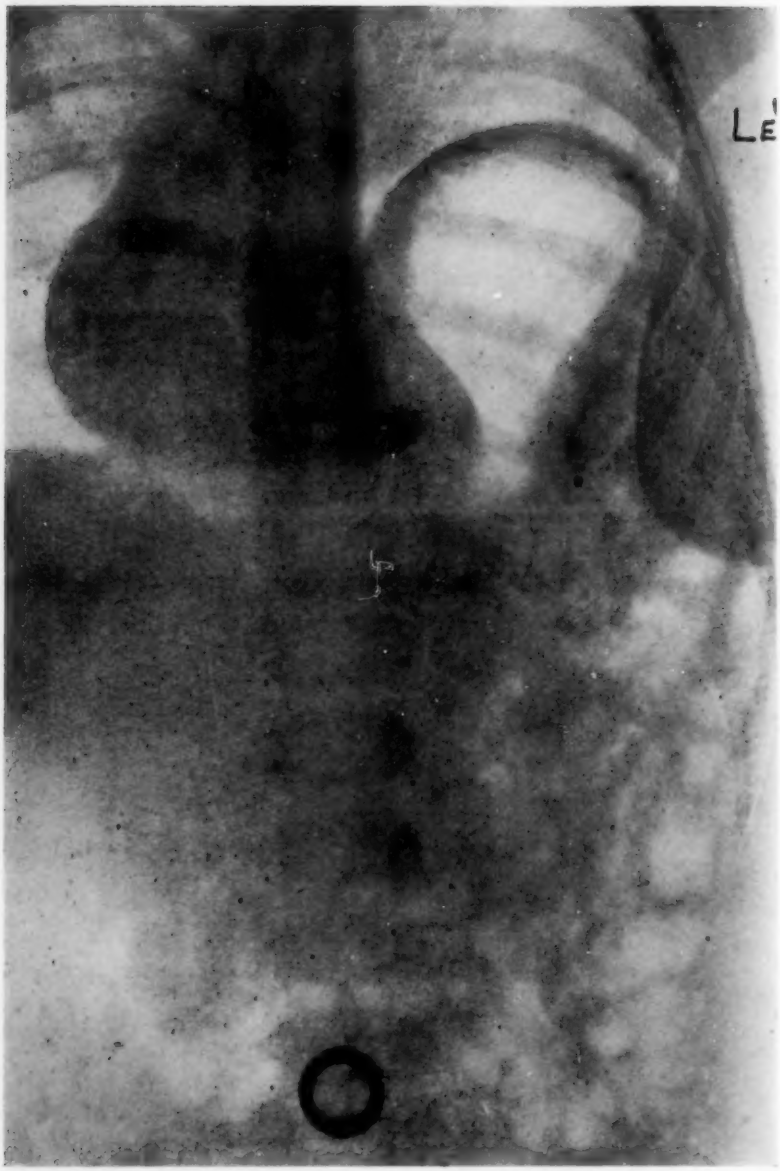

FIG. 4.—Case II. Showing intact diaphragm on left side with stomach, large bowel and spleen lying below. Heart almost entirely right-sided. Liver vertical. Large bowel is redundant.

as is shown by our latest X-ray views of the child now well. We are of the opinion that the condition at present represents what was present before operation, and is a typical eventration of the diaphragm with the stomach of regular outline and the top of it covered by the very high lying diaphragm. The child was treated expectantly, the superficial infection cleared up and the sinuses closed. The stomach relieved of the surrounding inflammation began to function correctly and the child is now perfectly well. At the first operation either the stomach was perforated after opening the chest wall, or the incision had led into the peritoneal cavity.

The second case, R. D., St. L. Ch. H. No. 19145-M, August 3, 1922, is a boy six years old who had first been studied because of malnutrition. On examination the heart was found in the right chest, and in the left chest tympany extended up to the third rib in front and down to the level of the twelfth rib. A succussion sound was demonstrated over the tympany, and in the upright position a line of dullness was made out below, which disappeared when the child lay down, and this was considered stomach and not an encapsulated pyopneumothorax. The X-ray examination showed an atypical high diaphragm rising to the level of the second intercostal space and below this the stomach, with the œsophagus entering opposite the eighth vertebra. The colon also reached to the level of the diaphragm but was displaced when the stomach was full. The spleen, normal in size, was seen hugging the lateral wall. The liver, of normal size, was entirely right-sided and extended to the crest of the ilium, The heart was in the right thorax. The child was discharged under instructions as to diet, and gained in weight and strength.

Four months later he was brought back because of an attack of abdominal pain, which simulated appendicitis. In the afternoon he had severe epigastric pain which moved later to the lower abdomen. There was general abdominal tenderness, nausea, but no vomiting. When he entered the hospital a few hours later he had a temperature of 101 degrees, leucocytosis of 17,400, with abdominal pain, but there was no consistent point of tenderness, at times he was more tender in the right lower quadrant, and then over a corresponding point on the left side. After a very large spontaneous stool the child felt quite comfortable. Examination of the rectum showed it to be very large. The external sphincter was very weak or absent but the internal sphincter was tight. In this case as in the previous one, the large bowel was generally dilated and redundant, as shown in the X-ray. We concluded that he had the cramping and pain occasionally seen with these large bowel distentions and we deferred operation. The temperature was explained by a reddened throat. The next day the boy seemed well. After another study with the X-ray, the boy went home.

Under usual conditions neither child presents any untoward symptoms from their anatomical anomalies.

Cruveilhier, in 1849, credits J. L. Petit with having described this condition found at autopsy in which the diaphragm on the left side was distended, forming a high lying flask-shaped pouch. There was no rupture of its membrane, and the diaphragm was considered to have lost its power of contraction. The stomach, colon, omentum, and spleen occupied the space usually filled by the left lung. The heart was in the right chest. Others have since described the condition and there has been much discussion of the name. Wieting [2] gave the name "relaxatio diaphragmatis" and Königer [3] "idiopathic high-lying diaphragm."

The condition is rare. When we compare these cases with hernias of the

diaphragm, we find according to Struppler,[4] there are forty-four eventrations to five hundred hernias of the diaphragm. Before the X-ray there were few cases diagnosed. Up to 1899, Neumann[5] found only eight cases in the literature and these were discovered accidentally at autopsy; since that time, up to 1919, forty-one cases have been reported of which nineteen have been confirmed by autopsy.

The condition is probably congenital in origin, at least it has been observed in very young children. There is a theory that is held by some that the diaphragm is paralyzed, due to the atrophy of the phrenic nerve, but in seven cases in which the nerve was examined, only four showed a decided change of this structure (Neumann). In both of our cases the diaphragm went through a typical excursion in the fluoroscopic examination, which differed from the opposite side only in being much more restricted. In many of the cases studied at autopsy, the diaphragm showed thinning and replacement of muscle tissue with fat.

Eventration occurs nearly always on the left side. In those cases in which the autopsy reports mention it, the lung is small but has two lobes.

This condition may exist without giving any symptoms, and advanced age may be reached without any evidence of trouble. Symptoms if present may be referred either to the chest or to the abdomen. Some cases have complained of discomfort in the left chest or have had a sense of pressure. Very rarely has there been any complaint of the heart which is pushed far to the right. Dyspnœa is often noted with inflammation of the left lung, and distress follows coughing as in bronchitis. Frequently, there are digestive disorders, with distress after eating. Occasionally the kinking of the lower end of the œsophagus gives symptoms similar to cancer of the œsophagus. The stomach, which is larger than usual, may be the seat of hemorrhages, or volvulus may develop. The large intestine may be dilated and symptoms may arise similar to those in Hirschsprung's disease.

In making the diagnosis, it is most important to consider the variations shown by percussion and auscultation. The heart is found in the right side of the chest. A large part of the left chest is tympanitic, and there is a dullness which varies with position of the body and with taking of food and liquid. This shifting dullness of the partly filled stomach may be mistaken for pyopneumothorax, as in one of our cases. Succussion if obtained must be located in the pleura or stomach, and the diagnosis cleared by the X-ray.

The chief confusion in diagnosis will be with diaphragmatic hernia. As both conditions may be congenital, and both exist for a long time without manifest symptoms, it is often impossible to distinguish between the two conditions without a thorough X-ray study. The continuity of the arch of the diaphragm in eventration or displacement marks the distinction between hernia, which, whether congenital or traumatic in origin, shows an irregularity in the diaphragm, and the mottled appearance of the lung may show through the gas contained in the stomach.

In a fluoroscopic examination the diaphragm moves with respiration, or

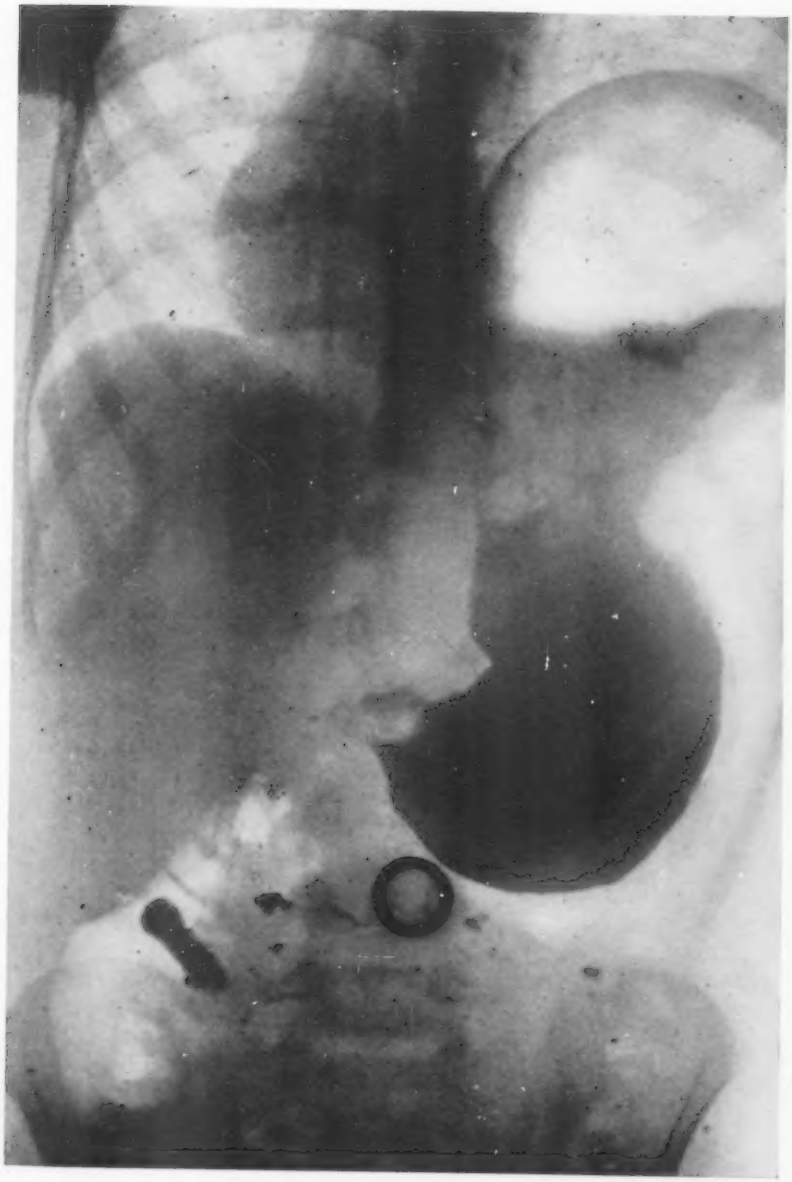

FIG. 5.—Case II. Showing particularly well the rounded intact dome of the left diaphragm, the large stomach and the vertical liver.

FIG. 6.—Case II. Lateral view to show the diaphragm intact and its very high position.

the excursion may be much reduced due to congenital hypoplasia of the left lung. In diaphragmatic hernia a "paradoxical expiratory displacement" has been noted, with forced inspiration the herniated diaphragm ascends, and descends with expiration.

The displacement of the heart may confuse eventration with situs transversus, but further examination will show the liver to be right-sided, and the stomach on the left.

The prognosis in cases of eventration is good, and death has never been observed as a direct consequence of the condition. Complications arise from the involvement of the organs that enter into the abnormal displacement, but are rarely more serious than are seen with normally placed viscera.

Nothing much need be said about treatment, as what there is should be entirely symptomatic. Eventration is not an operable deformity, in contradistinction to diaphragmatic hernia, which most often is. But eventration has been operated upon because of a diagnosis mistaking it for pyopneumothorax as in our first case, and as in a case reported by McNab.

For the prevention of serious complications, severe exertion should be avoided.

BIBLIOGRAPHY

[1] Cruveilhier: Traité d'Anatomie pathologique, tome 1, p. 617, 1849.
[2] Wieting: Ueber die Herniæ diaphragm. Deutsch Zeit. f. Chir., 82, 1906.
[3] Königer: Zur differential Diagnose der Zwerchfellhernia und die einzeitigen iodopathisher Zwechfellhochstandes. Muench. med. Woch., 6, 1909.
[4] Struppler: Über den physik. Befund und die neueren klin. Hilfsmittel bei der Diagnose Zwerchfellhernie. Deutsch Arch. f. Klin. Med., 70, 1901.
[5] Neumann: Zur Frage der Relaxatio Diaphragmatica. Deut. med. Woch., 1919.
[6] Bergmann: Über Relaxatio diaphragmatica (eventratio diaphragmatica). Eigeb. d. inn. Med. u. Kinderheilk., 12, 1913.

CARDIOPLASTY FOR CARDIOSPASM*

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The etiology, diagnosis, and non-operative treatment of cardiospasm have been thoroughly discussed in recent years by Plummer, Smithies, and many others, but comparatively little has been written regarding the operative treatment of the condition. This is quite natural considering that very few of the cases require surgery for their relief, in fact it is possible that surgery is justifiable only where the hydrostatic dilator cannot be passed through the cardia with the aid of a silk thread guide, as in my case, but experience at the Mayo Clinic shows that this must be extremely rare. Vinson has reported a case with very marked dilatation and angulation of the œsophagus in which he was able to pass the dilator on a flexible bougie.

Since a radical operation at the cardia is a rather formidable procedure it might be advisable in the rare cases in which a silk thread cannot be gotten into the stomach by way of the mouth, to open the stomach, stretch the cardia and pass a strong thread backward through the œsophagus, bringing the lower end of the thread out through a gastrostomy and leaving it as a guide for the hydrostatic dilator to be passed by the mouth.

The cases with great dilatation and atony of the œsophagus might seem to indicate surgery, but it is said by Plummer and Vinson that these respond particularly well to hydrostatic dilatation; however, in my case, in spite of a large opening at the site of the cardioplasty, the œsophagus is still quite dilated more than a year after operation, but the symptoms are perfectly relieved.

J. C. Russel, in 1898, first dilated the cardia by means of a rubber bag covered with silk. This method has been perfected by Plummer and others and has become the standard method of treating cardiospasm.

Gastrostomy alone in this condition is only a palliative measure. The first operation for the relief of the cardiospasm was published in 1904 by Mikulicz, who opened the stomach and thoroughly stretched the cardia by means of a rubber-shod clamp introduced into it under guidance of the finger. He reported six cases treated in this manner with good results in five. The poor result in the other case was attributed to scar formation due to suppuration. Most of the operators who have used this method have reported only single cases and as a rule have substituted their fingers for the instrument in stretching the cardia. Schloffer in two cases very gradually dilated until five fingers were passed into the cardia. In spite of this thorough stretching there was a tendency to recurrence. After some months there were few or no clinical symptoms, but the X-ray showed some delay in the œsophagus.

* Read before the American Surgical Association, May 31, 1923.

Pamperl, in 1919, collected fourteen cases operated upon by the Mikulicz method, of which twelve were said to be cured and two improved. In addition to these he reported the two cases of Schloffer mentioned above. Thieding, in 1921, collected three more cases successfully treated by this method. The operation was somewhat modified by Kümmell, who suggested that the stretching be done without opening the stomach by invaginating the stomach wall on the fingers. This has been tried twice with little or no success. In

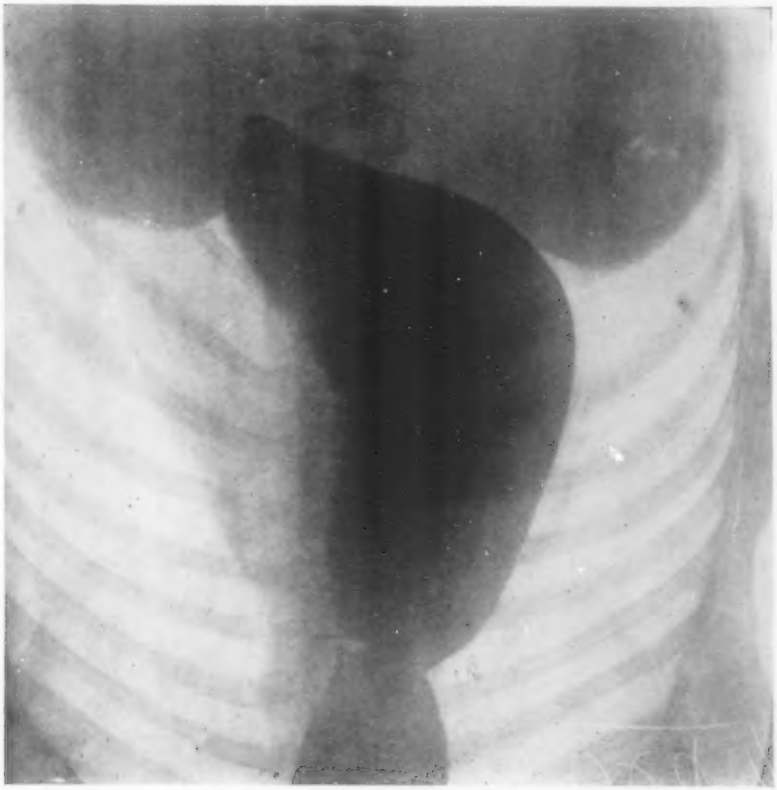

FIG. 1.—August 30, 1919. Enormous dilatation of œsophagus.

one of these cases, Schmielensky was unable to dilate the cardia in this way, therefore he opened the stomach and stretched the cardia with forceps. The œsophagus was torn and the patient died. This seems to be the only case on record in which death was caused by the Mikulicz operation.

In 1907, Reisinger reported a case of enormously dilated œsophagus with cardiospasm, in which he exposed the œsophagus in the posterior mediastinum by rib resection with the idea of plicating the œsophagus. This was prevented by collapse of the patient. Several weeks later a strip of the œsophageal wall, 15 cm. long by 2 to 3 cm. wide, was excised and the œsophagus sutured. On account of the breaking down of the suture many operations

were required to secure permanent healing after many weeks. The condition of the patient was said to be finally greatly improved by the operation.

The operation of œsophageal plication devised by Reisinger was later done by Meyer transpleurally under differential pressure. The vagi were separated from the œsophagus and the latter plicated. He reported three cases. One case was greatly improved for a good while, in fact was considered cured, but later developed an œsophageal fistula and died about a

FIG. 2.—October 13, 1920. Practically no change. Very small stream of opaque meal passing into stomach.

year after operation of posterior mediastinitis. In the second case there was some improvement in swallowing immediately after the operation but the former difficulty gradually returned. In the third case there was no improvement.

Plication of the œsophagus would not seem to offer much hope of success in these cases as it does not remove the cause of the trouble.

In 1910, Wendel reported the first cardioplasty for cardiospasm. After turning up the costal margin he exposed the cardia, which was narrowed to the size of a lead pencil over an extent of 4 cm. A vertical incision was made through the anterior wall of the cardia and sutured transversely. The

patient was cured. My case seems to be the only other one in which this type of operation is reported and in my case the operation was more after the order of the Finney pyloroplasty. Meyer has done a transpleural cardioplasty four times in dogs, with recovery in each instance, and suggests that this may be the proper procedure in certain cases of cardiospasm.

In 1914, Heller described an extramucous cardioplasty and reported a case of chronic cardiospasm with dilatation of the œsophagus treated in this

FIG. 3.—April 2, 1922. Three weeks after cardioplasty. Immediately after giving opaque meal. Considerable amount of meal in stomach.

manner. After turning up a flap of costal margin, the œsophagus was freed by division of the peritoneum at the hiatus œsophageus and by blunt dissection. It was drawn down and the musculature on the anterior and posterior aspects of the cardia was divided down to the submucosa over an extent of 8 cm. The day after operation, the patient could swallow any kind of nourishment without difficulty.

At the German Surgical Congress in 1921, Heller reported that this case was in good condition and free from symptoms seven years after operation, but the X-ray showed a constant narrowing at the cardia, of which there was no evidence just after the operation. He stated that he knew of

sixteen cases which had been operated upon in this way by various operators. There were no fatalities, the results were good in twelve cases and poor in four. One case of Zaaijer developed a cicatricial contraction of the cardia which required an œsophago-gastrostomy. Heller says that division of the musculature is not difficult but that the operation should not be done in early cases without marked dilatation of the lower œsophagus.

Herovsky, in 1913, reported a case operated upon in the following man-

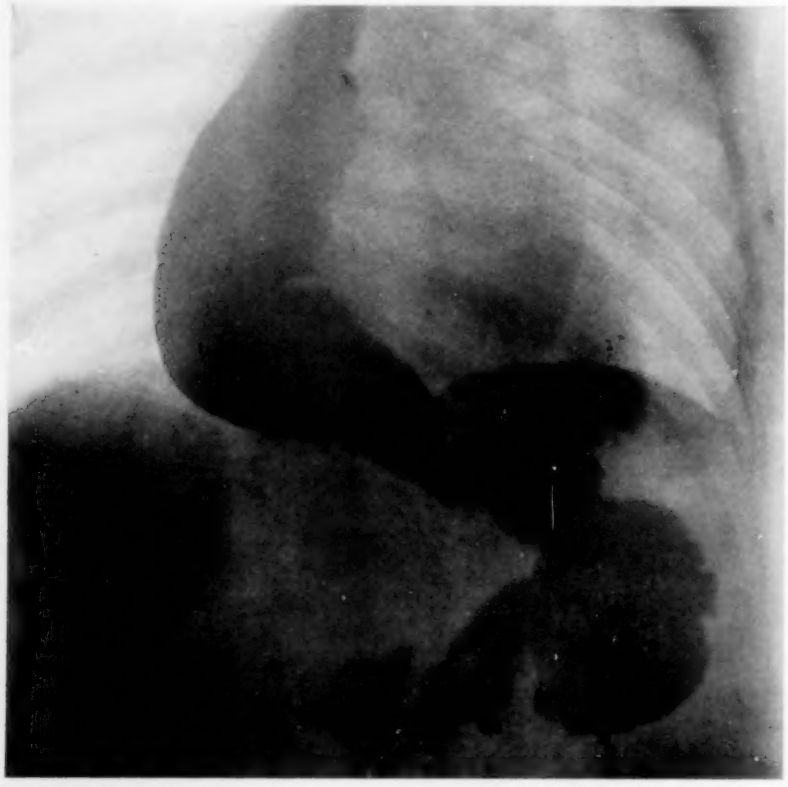

FIG. 4.—September 15, 1922. Six months after cardioplasty. Note marked shrinkage of œsophagus, the large opening at the cardia and the well filled stomach.

ner. After turning up the costal margin the œsophagus was loosened at the hiatus and anastomosed to the fundus of the stomach by suture. The patient was completely relieved. Later œsophago-gastrostomy for cardiospasm was done by Exner, Enderlin, Finsterer, Sauerbruch and a few others with rather satisfactory results. Of the three cases thus treated in Sauerbruch's clinic one died and the other two were greatly benefited. In 1914, Röpke, after making a costal flap, mobilized the œsophagus at the hiatus œsophageus, drew it down about 10 cm. into the abdomen, removed the periœsophageal tissue down to the musculature by blunt dissection and then incised the anterior edge of the hiatus. After this operation any kind

of food could be taken. Borchgrevink reports a case in which this operation was followed by sounding with perforation and death.

Resection of the cardia for cardiospasm, as proposed by Rumpel in 1897, has apparently not yet been done.

From this review it would seem that the simplest operative measure is stretching the cardia by way of the stomach, but this may be followed by a recurrence. The extramucous cardioplasty of Heller is probably the simplest

FIG. 5.—May 5, 1923. Practically no change since last picture.

and best radical operation, if it is as easy and efficient as the reports would lead us to believe. A cardioplasty, resembling the Finney pyloroplasty, as done in my case, would probably not be difficult in cases where the dilated œsophagus bulges through the hiatus, provided the costal margin is turned up to secure a better exposure, but the possibility of infection here presents an element of danger.

Case Report.—Mrs. M. D., white, aged thirty-nine years, was first admitted to the University of Virginia Hospital, August 27, 1919, complaining of shortness of breath and regurgitation of food. *Family History.*—Unimportant. *Previous History.*—Unimportant. *Present Illness.*—About fifteen years ago patient began to feel as if there were a lump in her throat after eating, as though the food had lodged behind the lower end of the sternum. Soon after this she began to

regurgitate her food. The condition gradually grew worse with increasing difficulty in getting food into the stomach. At the present time she eats about one-half of her meal then drinks about a quart of water, finishes the meal and drinks more water.

The regurgitated food comes back just as it was eaten; milk comes back thick but not sour. Most of the food comes back in from five to fifteen minutes after eating but some of it comes back at irregular intervals until the next meal.

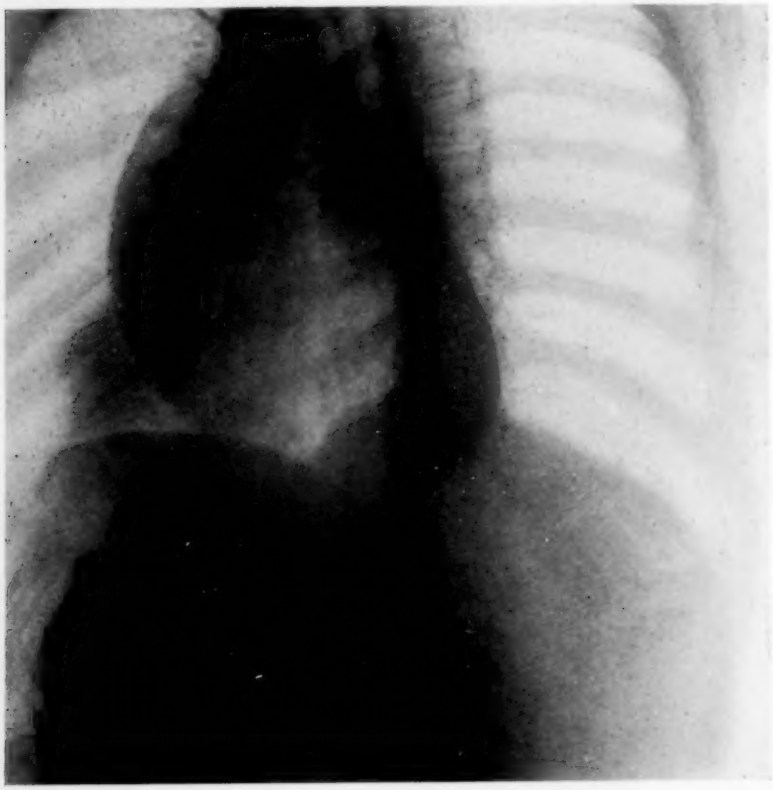

FIG. 6.—May 5, 1923. Small amount of opaque meal in lower œsophagus one-half hour after meal.

Often a part of her supper comes back the next morning just as it was eaten the night before.

The patient at this time was fairly well nourished. The X-ray photograph after giving one quart of opaque meal showed an enormous dilatation of the œsophagus, tapering down to a sharp point at the cardia and none of the barium was in the stomach (Fig. 1.). She left the hospital without treatment promising to return in two weeks for dilatation, however she did not come back for a year, *i. e.*, September 13, 1920. She had lost considerable weight and she had still more difficulty in getting food into the stomach, in fact she often found it necessary to make pressure in the suprasternal notch, where there was a distinct fullness. The X-ray examination gave the same picture as described above. Numerous attempts to pass bougies and to have her swallow a thread were unsuccessful, so she was transferred to the surgical service.

Operation (September 24, 1920).—*Gastrotomy; digital stretching of cardia; gastrostomy.* Incision was made through the upper portion of the left rectus muscle. The stomach was somewhat contracted but nothing like so much as had been expected. Examination of the cardia showed it to be quite narrow, apparently in spasm, but an interesting point was that about 4 cm. of the dilated œsophagus could be seen below the diaphragm. Cardioplasty was considered but was given up on account of the rather inaccessible location of the cardia. The stomach was opened near the cardia and two fingers were easily passed through the cardia which was stretched by separating the fingers. The opening in the stomach was closed and a Frank gastrostomy was done with the idea of thus feeding the patient and allowing the greatly distended œsophagus to contract.

The patient's condition was slightly but temporarily improved by this operation, perhaps due to insufficient stretching of the cardia. X-ray, October 13, 1920, (Fig. 2.) showed only a very small amount of the opaque meal passing into the stomach. She became dissatisfied, complained of pain caused by the gastrostomy tube, demanded its removal and left the hospital.

She came to the hospital again about a year later, November 9, 1921, complaining of inability to get food into the stomach, of sore mouth and sore, swollen hands. About three months before, when she was weighing 130 pounds, she became unable to force food into the stomach as she had formerly done, her mouth soon became sore and her hands and arms seemed inflamed. Her hands became worse, swollen, dry and cracked. She developed a diarrhœa, lost weight rapidly and became greatly depressed mentally.

Her weight on admission was seventy pounds. There was a glove-like area of dermatitis, involving the dorsum of the fingers, hands and forearms, extending to within three inches of the elbow. It was symmetrical on the two sides. The skin was thickened, rough, brownish, inelastic, scaly, and fissured, and the edge of the involved area was sharply demarcated. There was moderately marked stomatitis, involving chiefly the tongue, which was red, furrowed and swollen. There were all the cardinal symptoms, nervous, cutaneous, gastro-intestinal, and metabolic, of pellagra.

The gastrostomy was reopened on November 15, 1921, and a tube reinserted. She was given a diet with a high protein and vitamine, especially water soluble vitamine three, content. She improved rapidly and symptoms of pellagra gradually disappeared. In three months she had gained sixty pounds and weighed 130 pounds.

X-ray picture at this time was practically the same as on her first admission and attempts to pass an œsophageal dilator were again unsuccessful. At her urgent request a radical operation was undertaken.

Operation (March 13, 1922).—*Cardioplasty for Cardiospasm.*—Incision was made through the old scar and the stomach separated from the abdominal wall, an opening 4 cm. long being left in the stomach at the site of the gastrostomy. Numerous adhesions were encountered in the upper left abdomen but with considerable difficulty these were separated and the cardia exposed. It seemed rather narrow and the bulging œsophagus could be seen above it. An incision 4 cm. in length was made through the anterior aspect of the cardia, extending equally into the œsophagus and stomach. These structures were approximated and sutured together with chromic gut very much after the manner of a Finney pyloroplasty. The old gastrostomy opening was closed and a new Frank gastrostomy made. A cigarette drain was inserted through a stab wound in the left flank and the abdomen closed.

She made an excellent recovery, in two weeks was able to take any kind of soft diet and it was then unnecessary to use the gastrostomy. X-ray picture (Fig. 3)

taken immediately after the giving of the opaque meal on April 2, 1922, three weeks after the operation, showed a considerable amount in the stomach.

She left the hospital April 29, 1922 and since that time has had no trouble whatever referable to her œsophagus, though she did enter the hospital about a month later with a definite appendix abscess which was absorbed without operation.

X-ray picture, September 15, 1922, (Fig. 4) showed marked shrinkage of the œsophagus, a large opening at the cardia, and a well filled stomach. The patient was last seen on May 5, 1923 when she stated that she was perfectly well and could swallow any kind of food without difficulty. Her weight was 166 pounds. X-ray gave practically the same picture (Fig. 5.) as in September, 1922, and we were somewhat disappointed that there had apparently been little or no further shrinkage of the œsophagus. The picture one-half hour after the meal (Fig. 6) showed a small amount of the meal in the lower œsophagus.

BIBLIOGRAPHY

Erdman, J. F.: Cardiospasm. Annals of Surgery, 1906, vol. xliii, p. 224.

Exner: Beitrag zur subphrenischen Oesophagogastrostomie. Wien. klin. Wochenschr., 1917, S. 886.

Heller: Extramuköse Cardiaplastik beim chronischen Cardiospasmus mit Dilatation des Oesophagus. Mittheil. a. d. Grenzgeb. d. Med. u. Chir., 1914, Bd. xxvii, S. 141.

Heller: Verhandl. d. Deutschen Gesellsch. f. Chir., 1921, Bd. xlv, S. 144.

Herovsky: Kasuistik und Therapie der idiopathischen Dilatation der Speiseröhre. Oesophagogastroanastomose. Arch. f. klin. Chir., 1913, Bd. c, S. 703.

Iden: Cardiospasm. Jour. Am. Med. Assoc., 1911, vol. lvi, p. 1438.

Kümmell: Zur Operation des Kardiospasmus und des Oesophaguscarcinoms. Arch. f. klin. Chir., 1921, Bd. cxvii, S. 193.

Meyer W.: The Operative Treatment of Intractable Cardiospasm. Am. Jour. of Surg., 1912, vol. xxvi, p. 193.

Mikulicz: Zur Pathologie und Therapie d. Cardiospasmus. Deutsche med. Wochenschr., 1904, Bd. xxx, S. 17.

Pamperl: Zur operativen Behandlung des Kardiospasmus. Deutsche Zeitschr. f. Chir., 1919, Bd. cxlviii, S. 206.

Plummer and Vinson: Cardiospasm: A Report of 301 Cases. M. Clinics N. America, 1921, vol. v, p. 355.

Reisinger: Ueber die operative Behandlung der Erweiterung des Oesophagus. Verhandl. d. Deutschen Gesellsch. f. Chir., 1907, S. 86.

Röpke: Zur Operation des Oesophagospasmus. Verhandl d. Deutschen Gesellsch. f. Chir., 1914, S. 121.

Russel, J. C.: Diagnosis and Treatment of Spasmodic Stricture of the Œsophagus. Brit. Med. Jour., 1898, vol. i, p. 1450.

Smithies: Diagnosis and Clinical Manifestations of Cardiospasm Associated with Diffuse Dilatation of the Œsophagus. Am. Jour. Med. Sc., 1921, vol. clxii, p. 313.

Thieding: Ueber Cardiospasmus, Atonie und "idiopathische" Dilatation der Speiseröhre. Beitr. z. klin. Chir., 1921, Bd. cxxi, S. 237.

Vinson: A Case of Cardiospasm with Dilatation and Angulation of the Œsophagus M. Clinics N. America, 1919, vol. iii, p. 623.

Wendel: Zur Chirurgie des Oesophagus. Arch. f. klin. Chir., 1910, Bd. xciii, S. 311.

AN OPERATION FOR THE RELIEF OF CARDIOSPASM ASSOCIATED WITH DILATATION AND TORTUOSITY OF THE ŒSOPHAGUS*

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About twenty years ago, a man, thirty-four years of age, came under my care for a severe cardiospasm, which had seriously annoyed him for ten years. Although there had been intervals when he could swallow reasonably well, nevertheless the trouble had steadily increased until he could not be sure of swallowing anything but liquids, and these only with great and prolonged effort. He had become so extremely weak and emaciated that he could accomplish no sort of labor, and it was with the greatest difficulty only that he could get about at all. Profuse salivation, especially at night, and frequent, copious emesis, from the dilated œsophagus, were among the annoying symptoms.

There was no evidence of cancer or other form of tumor in connection with the œsophagus; neither was there a history of syphilis, typhoid, diphtheria, or injury by any corrosive substance, or anything else that might have caused the formation of a stricture. In addition to this, a large gastric tube could at all times be passed into the stomach without much difficulty.

The character of the symptoms, together with the permeability of the canal and the length of time during which the lesion had persisted, pointed either to a cardiospasm with much dilatation or to a large low-lying diverticulum. The X-ray, at that time, not being available for more accurate diagnosis, an exploratory operation was decided upon.

Operation (July 14, 1902).—The œsophagus was easily uncovered through the usual vertical incision on the left side of the base of the neck. No diverticulum was found; but, beginning just above the cricoid and extending further down behind the sternum than the finger could reach, the œsophagus was uniformly dilated into a great, slack, thin-walled, sac-like tube, around which the examining finger easily could be swept within the mediastinum.

Still searching for a possible diverticulum, which did not exist, I pulled upwards on the dilated tube until a large fold, including the entire circumference, protruded through the incision in the neck, and the portion below was rendered quite taut. There was no difficulty in accomplishing this, owing to the surprisingly loose manner in which the œsophagus seemed to hang within the mediastinum.

Having arrived at this point, with the loop of œsophagus lying exposed upon the neck, I was embarrassed as to what to do next. I did not want to resect the loop, because of the danger of infection, and yet the situation called for action of some sort. Finally it was decided to invaginate the upper segment of the loop into the lower, without opening its lumen, thus restoring to the tube something of its proper length and longitudinal tension. This intussusception, maintained by means of a few stitches of chromic gut, formed such a bunch in the œsophagus that I feared its complete occlusion, so a stomach-tube was passed and left in place for a few days, although I now question the necessity of such a procedure.

The wound was closed and healed by primary union. The patient soon recovered his full ability to swallow and in a few weeks had regained his strength and

* Read before the American Surgical Association, May 31, 1923.

energy. Up to the present time, twenty years, he has had no return of his trouble except an occasional slight dysphagia. He has been able to live his life and do his work with ease and comfort.

The outcome of this case perplexed me much. It seemed evident that the operation had brought about a cure, but I did not understand how. If the trouble always was due to a spasm of the cardiac muscle, as believed at that time, why should it be cured by a mere invagination of the dilated œsophagus higher up? Finally I connected it up vaguely with the shortening and narrowing of the œsophagus and let it go at that. I did not report the occurrence, because I did not clearly understand it.

Recently I came across an article by Herman Kümmell (Archiv klin. Chir., B. 117, H. 2, p. 193.) which throws light upon the subject and has given me a new interest in it. Among other things he emphasized the tendency to failure of the current forms of treatment, such as the various methods of dilatation from above and from below, the division of the sphincter muscle, etc. But my attention was attracted particularly to a paragraph dealing with the pathology of the affection, in which it is stated that the difficulty in swallowing may be due to either of two conditions or to their combination. One of these is cardiospasm, followed more or less closely by dilatation; and the other is where the œsophagus is not only dilated, but also convoluted, as though it were much too long for the mediastinum. This latter form, often of congenital origin, may or may not be preceded or accompanied by spasm of the cardiac muscle, the difficulty in swallowing being due more to the peculiarities of the dilated and convoluted tube than to the muscular spasm of its outlet.

Kümmell then recounts a case of the second variety in which, after the failure of other treatments, he attempted to obtain a cure by opening the abdomen, loosening the cardia from its diaphragmatic connection, pulling down the redundant œsophagus, dividing it at the stomach, and anastomosing it with the jejunum. The stomach itself he shifted upwards to the neck, through a subcutaneous tunnel over the sternum, with the intention of ultimately uniting it to the cervical œsophagus. But for some reason this highly ingenious and complicated procedure failed to produce a permanent result, although the patient was fortunate enough to survive. A number of similar operations also have been done, with more or less success, by various other surgeons (Sencert, Oettinger, Caballero, Sauerbruch, Exner, Tuffier, etc.), having the common objective of straightening out the œsophagus by pulling its redundant portion down into the abdominal cavity and perhaps anastomosing it to the stomach or to the duodenum. Reisinger plicated the œsophagus, with an indifferent result, through an opening into the posterior mediastinum, the operation being done in two stages owing to the collapse of the patient. Willy Meyer, in the International Journal of Surgery, 1912, describes two longitudinal plications done by the transpleural route, the results being rather unsatisfactory. More recently, Pribam (Archiv klin. Chir., 1922, B. 120, H. 2, p. 207) says, "It might also be considered if one could not,

after exposure and mobilization of the œsophagus in the neck, pull it upwards and thus do away with its tortuosity. A resection of the œsophagus in the neck would be accompanied by but little danger" [!] He adds, however, that this has not yet been tried.

If the assertion of Kümmell is true that the dysphagia in some instances is due more to undue length and tortuosity of the gullet than to spasm of the cardia, the satisfactory result obtained in my own case by telescoping the œsophagus into itself is easily understood. By means of this procedure, not only was the length of the tube lessened and its tortuosity removed, but at least a portion of its calibre was considerably diminished, thus increasing the muscular tone and doing away with obstruction arising from the slack folds. At any rate the effect was good and permanent. The operation also has the advantage of simplicity and safety, the danger of infection practically being absent, because it is unnecessary to open the œsophagus. To be sure, one case does not prove much, but I venture to report it in the hope that further experience with the method may show it to be of value under appropriate circumstances.

PANCREATIC ASTHENIA AS A POST-OPERATIVE COMPLICATION IN PATIENTS WITH LESIONS OF THE PANCREAS*

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Certain symptoms have been recognized for many years as occurring in pancreatic disease. These are asthenia, anorexia, nausea and vomiting, a tendency to hemorrhage, ptyalism, abnormal stools, epigastric pain and tenderness and rapid emaciation. One or more of these symptoms are mentioned by the numerous investigators in their discussions of the clinical picture of inflammatory and neoplastic lesions of the pancreas. But so far as the writer has been able to determine in a review of the literature a group of these symptoms has not been described as a syndrome appearing as a post-operative complication in the surgical therapy of the biliary tract and pancreas. In discussing the subject with several of the members of this Association, it is evident that this symptom complex has been noted by many of them and is considered a puzzling and difficult problem in the post-operative therapy of their biliary cases.

I desire to present an analysis of 18 cases with this complication from the Surgical Service of the Presbyterian Hospital, New York City. Seventeen of these patients were under my care, the eighteenth was recently operated upon by Dr. F. B. St. John and is included in this series with his kind permission.

In a series of 230 consecutive unselected cases of diseases of the biliary tract and pancreas operated upon by the writer, special attention has been paid to the pathology, symptoms, complications and results as related to the pancreas. Of these 230 cases 40 showed definite pancreatic lesions. The cases with questionable or moderate thickening of the pancreatic tissue about the common duct are not included. (See Table I.) Eighteen of these cases presented the complication which because of its most striking and constant symptom, asthenia, has been named pancreatic asthenia. At the Presbyterian Hospital we regard it as an entity. It is characterized by extreme asthenia, anorexia—in some cases a very loathing for all food, apathy, nausea and vomiting, a marked drop in blood-pressure, rapid loss of weight. In some cases there has been noted in addition a tendency to hemorrhage, with and without jaundice or biliary fistula, ptyalism, pain and tenderness over the pancreas, obstipation and diarrhœa. (See Table II.)

Pancreatic asthenia has appeared in our cases at intervals after operation varying from the second to the ninth day, and has lasted for periods varying

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TABLE I

Pathology of the 40 Cases with Pancreatic Lesions

Acute Inflammatory Lesions.		7
Hemorrhagic pancreatitis	2	
Suppurative pancreatitis with fat necrosis	4	
Abscess of the pancreas	1	
Chronic inflammatory lesions		17
Chronic pancreatitis without cholecystitis or cholelithiasis	4	
Chronic pancreatitis with cholecystitis and cholelithiasis	7	
Pancreatic lymphangitis involving the entire head with cholecystitis and cholelithiasis	6	
Diabetes mellitus with cholecystitis and cholelithiasis		5
Carcinoma of the pancreas		11
Primary carcinoma of the pancreas	8	
Primary carcinoma of the gall-bladder with metastases to the pancreas	2	
Primary carcinoma of the stomach with metastasis to the pancreas	1	

TABLE II

Analysis of Symptoms in 18 Cases of Pancreatic Asthenia

Asthenia was present in 18 cases.
Anorexia was present in 18 cases.
Apathy was present in 15 cases.
Nausea and vomiting was present in 18 cases.
Loss of weight was present in 18 cases.
Marked and continued fall in blood pressure was found in all of the last 7 cases on whom daily determinations were made.
Tendency to hemorrhage present in 6 cases.
Ptyalism present in 2 cases.
Pain and tenderness over the pancreas present in 3 cases.
Jaundice appeared after operation, present in 5 cases.
Obstipation was present in 2 cases.
Diarrhœa was present in 2 cases.

from two to thirty days, the average period being twelve days. The symptoms appear, as a rule, after the patient has recovered from the shock of the operation, when he is apparently doing well. In the patients recovering from this condition the change for the better is often surprisingly abrupt, appearing with a sudden return of appetite and relish for food. It differs from the cholemic state that one sees in cases with long-standing biliary obstruction and damaged liver. These patients with pancreatic asthenia are never comatose. They maintain a clear sensorium, are never delirious. Languor and apathy are pronounced. Weakness is their chief complaint. Asthenia, anorexia, nausea, drop in blood-pressure have been the first symptoms to appear. The asthenia is as marked in some cases as it is in Addison's disease. It is a subjective symptom causing the patient real concern. It is objectively manifested by the muscular relaxation, the mask-like facial expression, the feeble drawling voice, the weakened grip. All effort is avoided. Treatments are dreaded and exhausting. Oser, in his monograph on pancreatic disease, described this asthenia, but not in the post-operative

period. In discussing Chronic Indurative Pancreatitis he says:[1] "It is a well-known fact that many patients suffering from gall-stone, even without permanent jaundice, become so very weak and rapidly emaciated that the development of cancer is suspected, and yet after a long time patients wholly recover." Again in discussing asthenia in carcinoma of the pancreas, he remarks: "One peculiarity especially is frequently pronounced and manifest in the cachexia caused by pancreatic cancer, namely, the great weakness and prostration which cannot be explained by the inanition alone. The sensation of weakness may be too great for words—the patient avoids expression of suffering because it is worse to bear than the violent pain. The patients lie quiet and apathetic."[2] Apathy and languor have been noted in all of our cases, and is considered a result of the asthenia.

Anorexia is a constant symptom. In several of our patients there has been an aversion for all food, even fluids. This has been noted as independent of the nausea. Oser,[3] in speaking of anorexia in pancreatic disease, mentions "a loathing for food, especially for meats." Nausea and vomiting may be very marked; it has been present in all of our cases and has complicated the maintaining of fluid intake.

Blood-pressure studies have been carried out in our last seven cases. There has been a constant finding of marked drop in blood-pressure readings during the pancreatic asthenia as compared to the pre-operative readings. In one patient with a pressure of 215/130 before operation readings of 110/80 to 120/80 were noted during the course of her asthenia which lasted three weeks. Subsequent to her leaving the hospital her pressure rose to 200/120. In another patient pre-operative readings showed 110/70. During the most marked manifestations of his asthenia his systolic pressure fell to 50 with an imperceptible diastolic. No other observations on low blood-pressure in pancreatic disease after operation have been found in the literature.

A tendency to hemorrhage has been noted in two of our cases without jaundice, in four with jaundice. Prolonged bleeding and clotting time was a serious complication in these six cases. Jaundice appeared for a few days during the period of asthenia in four of our cases in whom stones were not found in gall-bladder or ducts at time of operation. In one of these patients jaundice continued for almost two years after the onset of the pancreatic complication. Ptyalism or excessive salivation was present in two of our cases during the pancreatic asthenia. This symptom is one of the earliest attributed to pancreatic disease. Schmackpfeffer,[4] in 1817, first called attention to it. Battersby,[5] in 1844, noted ptyalism in a case of pancreatic cyst, as did Ludolf,[6] in 1890. Halzmann,[7] in 1894, Caparelli,[8] in 1892, Guidiceandra,[9] in 1896, discussed this symptom in cases of pancreatic calculus. Friedrich,[10] in 1878, considered it a result of stomach involvement. Oser[11] explains it on the basis of associated nausea. A low sugar tolerance was determined in one of the eighteen cases after the asthenia disappeared. Pancreatic asthenia did not occur, however, in any of the five diabetics operated upon for gall-stone disease.

TABLE III

Analysis of Pathological Findings in 18 Cases of Pancreatic Asthenia

Case	Operative findings and operation	Result	Autopsy findings
1	Abscess in head of pancreas. Drainage of abscess.	Recovery 24 mos.	
2	Chronic pancreatitis involving the entire pancreas. Gall-bladder full of calculi. Cholecystectomy, choledochostomy.	Died	Hemorrhage in the interlobular septa. Ducts dilated. Acute interstitial pancreatitis.
3	Fat necrosis in omentum. Head of pancreas hard, nodular œdematous, gall-stones in the gall-bladder and common duct, cholecystectomy, choledochostomy.	Recovery 19 mos.	
4	Chronic cholecystitis. No calculi were found in gall-bladder or ducts. Lymph-nodes were enlarged along cystic and common ducts. Lymphangitis of the head of the pancreas. Cholecystectomy, appendicectomy.		She developed jaundice with asthenia and loss of weight. Lived 26 months. Died of chronic pancreatitis. Autopsy not obtained.
5	Chronic cholecystitis, calculi in gall-bladder and common duct. Entire pancreas was markedly enlarged, œdematous, indurated. Nodes were enlarged along the duct and over the head of the pancreas. Cholecystectomy, choledochostomy.	Died 20th day	Pancreas firm, nodular, enlarged, considerable increase in the interlobular connective tissue, especially in the body and tail.
6	Chronic cholecystitis, calculi in gall-bladder, one in common duct. The entire pancreas was hard, nodular, enlarged throughout. Cholecystectomy, choledochostomy.	Recovery 17 mos.	
7	Hydrops of gall-bladder. No calculi, common duct dilated, no calculi, pancreas showed a large, hard, nodular head with a cyst in its upper aspect. Cholecystduodenostomy.	Died	Patient recovered after her pancreatic asthenia. Tumor mass which had been palpable before operation disappeared in epigastrium for several months. Symptoms of asthenia recurred at end of 18 months and she died one month later. Autopsy not obtained as she died in a small suburb.

Case	Operative findings and operation	Result	Autopsy findings
8	Acute and chronic cholecystitis. Chronic cholangitis (B. coli communis). Calculi in gall-bladder and common duct. Enlarged nodes along common duct and over head of pancreas. Lymphangitis of entire head of pancreas. Cholecystectomy, choledochostomy.	Recovery 42 mos.	
9	Walls of gall-bladder calcareous gall-stone 5 x 4 x 4 cm. occupied the shrunken gall-bladder and compressed the common duct. Lymphangitis of the head of pancreas. She had been jaundiced eight months. Liver markedly enlarged. Cholecystostomy.	Recovery 56 mos.	
10	Chronic cholecystitis. Calculi in gall-bladder and common duct, lymphangitis of entire head of the pancreas. Cholecystectomy, choledochostomy.		
11	Chronic cholecystitis. Chronic pancreatitis, entire head and tail hard, nodular and enlarged. Cholecystectomy, choledochostomy.	Recovered 21 mos.	
12	Chronic cholecystitis. Single cholesterin stone in gall-bladder, 2 months pregnancy. Cholecystectomy.	Died 28th day	Developed pancreatic asthenia with jaundice on 2nd day. This persisted until 26th day. She then had very severe epigastric pain, developed hemorrhage and went into collapse. Autopsy.—Acute diffuse cholangitis hæmatoma in submucosa of the duodenum, closing lumen of the bowel. Hemorrhages into the retroperitoneal tissues. Fat necrosis. Sclerosis of pancreas with hemorrhage in it.
13	Gall-bladder distended, acutely inflamed. No calculi found in gall-bladder or ducts. Head of pancreas very hard, nodular, common duct dilated. Diagnosis: Acute cholecystitis carcinoma of pancreas. Cholecystectomy, choledochostomy.	Died 14th day	She showed hemorrhages into bowel and subcutaneous tissues.

Case	Operative findings and operation	Result	Autopsy findings
14	Carcinoma of gall-bladder. Chronic cholecystitis. Calculi in gall-bladder. Chronic pancreatitis. Cholecystectomy, transduodenal. Choledochostomy.	Died 19th day	*Autopsy.* Chronic pancreatitis, acute pancreatitis. Necrosis and liquefaction of periduodenal tissue and duct of Wirsung. Carcinoma of pancreas, liver, ovary and adrenal.
15	Carcinoma of body of pancreas. Exploratory celiotomy.	Died 15th day	
16	Carcinoma of pancreas. Cholecystgastrostomy.	Died 2nd day	
17	Carcinoma of gall-bladder. Carcinoma of common duct. Calculi in gall-bladder. Cholecystectomy, choledochostomy.		She developed typical pancreatic asthenia on 2nd day. These symptoms continued for 16 days, when she was taken to her home by her family. She died 2 mos. later. Whether or not the pancreas was involved in this case not determined, as autopsy was not obtainable.
18	Carcinoma of pancreas, cholecystostomy.	Died 20th day	

Course of the Complication.—The symptoms showed a duration of 2 to 30 days, the average period being 12 days. Save in carcinoma cases the syndrome cleared abruptly with the return of appetite. In several of the cases this change was striking. The request for bizarre dishes is often the first indication of subjective improvement. Thus Case I, after three weeks of refusing all food, even the simplest fluids, one morning informed us she was hungry and desired a dish of tripe. When this was prepared by her daughter she ate it with gusto and proceeded to an uninterrupted recovery. Case VI, after eleven days of complete anorexia, asked for a piece of juicy steak. He recovered progressively thereafter. The rapid gain in weight and sense of well-being have in several of our cases been as striking as was the loss of weight, asthenia and apathy during the course of the complication.

Pathology.—The pathological findings in these eighteen cases as determined at operation or post-mortem have been variable and in several of the cases very puzzling. Speculation as to the pathological findings in a given case of pancreatic disease is as hazardous to-day as in Fitz's time, who after 27 years of investigating, in his masterly way, the pathology of the pancreas remarked [12] in 1903 that "morbid changes in the pancreas are found frequently after death without symptoms having been observed during life to

indicate their presence. On the other hand, the diagnosis of probable pancreatic disease, perhaps of the gravest sort, has been made from the recognition of one or more symptoms or signs which at times have been associated with alterations of the pancreas and the patient has recovered or the gland when exposed has presented no abnormal appearance." Yet it will be seen from the analysis of the pathological findings in Table III that definite pathology was found in the pancreas in all but Case XVII. Whether or not the carcinoma of the common duct in this case, found near the lower end of the duct, extended into the pancreas was not determined at the operation. The patient died at home two months after leaving the hospital and autopsy was not obtained.

Treatment.—This is largely directed to the relief of fluid depletion. Continual vomiting and disinclination to take fluids results in low urine output and nitrogen retention. Glucose infusions in 5 to 10 per cent. solutions have been well taken without glycosuria. This would indicate that the islands of Langerhans are not involved in these pancreatic lesions. Blood transfusion has tided over several of our cases during the critical period of asthenia, especially those in whom it has persisted for more than 10 days. Lavage of the stomach, with hot saline solution or tap water, has not controlled the vomiting as effectively as in other abdominal cases where ileus or gastric dilatation is a factor. For the tendency to hemorrhage we have

TABLE IV

Mortality Statistics in 18 Cases of Pancreatic Asthenia

Case 2	Died 14 day	Acute pancreatitis found at autopsy.
Case 5	Died 20 day	Chronic pancreatitis found at autopsy.
Case 12	Died 28 day	Acute pancreatitis found at autopsy. Acute ileus.
Case 13	Died 14 day	Carcinoma of pancreas found at operation. Hemorrhages into bowel, and subcutaneous tissue.
Case 14	Died 19 day	Carcinoma of gall-bladder found at autopsy. Chronic pancreatitis.
Case 15	Died 15 day	Carcinoma of body of pancreas found at operation.
Case 16	Died 2 day	Carcinoma of pancreas found at operation.
Case 18	Died	Carcinoma of pancreas found at operation.

Post-operative results in the 10 cases leaving the hospital

Case 1 24 mos.
Case 3 19 mos.
Case 4 Died at end of 26 months of a chronic pancreatitis.
Case 6 14 mos. 244 Has weakness in the scar.
Case 7 18 mos. after operation tender mass reappeared in the epigastrium with jaundice and asthenia. Died one month later.
Case 8 42 mos.
Case 9 56 mos.
Case 10 12 mos.
Case 11 24 mos.
Case 17 Died 2 mos. after leaving the hospital of carcinoma.

found [18] intravenous infusions of calcium lactate in 0.2 to 0.5 per cent. solution shortened the bleeding and clotting time and has controlled the hemorrhage in all but three cases, all of whom showed carcinoma of the pancreas.

Epigastric pain and tenderness is best relieved with poultices. Tympanites responds to hot colon irrigations in some, to medicated enemas in others. We have found digitalis in the form of digitan given by rectum in 10 c.c. doses, has improved the general vasomotor and intestinal tone in a number of our cases.

Results.—It will be seen from Table IV that of 18 patients showing this syndrome 8 died while in the hospital, 5 showing carcinoma; 3 died after leaving the hospital in from 2 to 26 months. All of the surviving 7 patients show a symptomatic 4, relief from all symptoms, from 12 to 56 months after operation. From Table V it is evident that the lesions of the pancreas increase to a marked degree the hazard of the surgery of the biliary tract. In the entire series of 230 cases analyzed there were 25 deaths in the hospital, of these 25 fatal cases 15, or 60 per cent., showed pancreatic involvement. (See Table V.) Of 172 cholecystectomies, however, with the pathology limited to the gall-bladder at time of operation, there was but one death—Case XII reported in the series with pancreatic asthenia—the result of an acute pancreatitis developing after operation.

TABLE V

Death Analysis in 25 post-operative deaths in a series of 230 patients operated upon for Disease of the Biliary Tract and Pancreas.

15 of these cases showed pancreatic involvement.
11 showed carcinoma of the pancreas.
2 showed acute pancreatitis.
2 showed chronic pancreatitis.

Of the remaining 10 cases,

1 showed carcinoma of the cystic duct.
1 died of sepsis with B. coli chronic cholangitis.
3 died of cholemia with long standing biliary cirrhosis and common duct stone obstruction.
1 died of uremia following secondary cholecystectomy for common duct stone.
1 died of Welch bacillus cholecystitis and cellulitis.
1 died of vibrion septique cholangitis and cellulitis.
1 died of B. coli bacteria and acute endocarditis.
1 died of multiple liver abscess.

In 172 cholecystectomies for inflammatory disease or calculus limited to the gall-bladder there was but one death, the result of an acute pancreatitis developing after operation.

CONCLUSIONS

1. There is a group of symptoms appearing as a post-operative complication in patients with pancreatic lesions, characterized by asthenia, anorexia, nausea and vomiting, low blood-pressure and rapid loss of weight.

2. In a series of 18 cases reported definite pathology of the pancreas was determined in 17 either at operation or post-mortem.

3. The asthenia, anorexia, low blood-pressure and loss of weight is not dependent upon malignancy, inasmuch as 12 of the 18 cases reported showed pancreatitis rather than carcinoma.

4. The involvement of the pancreas increases to a marked degree the hazard of biliary surgery.

5. The inflammatory lesions and calculus formation limited to the gall-bladder should be treated surgically before the process of inflammation extends to the pancreas.

REFERENCES

[1] Oser, L.: Diseases of the Pancreas. Nottnagels Practice. Diseases of the Pancreas, Adrenal and Liver, p. 147.
[2] *Loc. cit.*, p. 162.
[3] *Loc. cit.*, p. 154.
[4] Diss. Inaug. de quibusd. Pancreatis Morbis, 1817, 26.
[5] Battersby, F.: Gazette Médicale de Paris, 1844, vol. xxxix, p. 617.
[6] Ludolf: Dissert., 1890.
[7] Halzmann, M.: Munsch. Med. Woch., 1894, No. 20, p. 389.
[8] Caparelli.
[9] Guidiceandra.
[10] Friedrich.
[11] *Loc. cit.*
[12] Fitz, Reginald H.: Transactions of the Congress of Am. Phys. and Surg., 1903, p. 36.
[13] Whipple, A. O.: ANNALS OF SURGERY.

SPLENECTOMY IN HEMORRHAGIC PURPURA*

IDIOPATHIC PURPURA, ESSENTIAL THROMBOPENIE (FRANK). PURPURA HEMORRHAGIC PROTOPATHIQUE (HAYEM)

By James Morley Hitzrot, M.D.
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The hemorrhagic diatheses have always been of considerable importance to the surgeon, because of the bleeding which occurs in these conditions following simple surgical procedures. This interest has recently been stimulated by Kaznelson, who recommended splenectomy upon a patient with essentielle thrombopenie (Frank) in October, 1916, with rather striking results.

Hayem has given a fairly definite set of clinical phenomena as characteristic of essential or idiopathic purpura (purpura hemorrhagique protopathique). The patient has an anæmia of the secondary type, with multiple spontaneous hemorrhages into the skin, from the mucous membranes, etc., recurring at irregular intervals with the following essential features: 1. Absence of any changes in the red blood-cells. 2. Marked diminution in the number of the blood platelets. 3. No constant variation in the white blood-cells. 4. Normal coagulation time of the blood. 5. A marked increase in the bleeding time. 6. Loss of contractility of the blood clot.

Frank, under the term "Die essentielle Thrombopenie," separates this type from the other varieties of purpura and considers it a clinical entity.

Fonio separates the hemorrhagic diatheses (other than hæmophilia) into three groups:

1. The Secondary Purpuras.—These have a known etiology and include the purpuras which occur in the febrile diseases (small-pox, typhus, ulcerative endocarditis, etc.), in peritonitis, in blood diseases (the leukæmias, pernicious anæmia); in diseases of the liver; due to the action of such poisons as phosphorus, benzol, snake venom, etc.; in scurvy, melena neonatorum, etc.

2. The Anaphylactoid Purpuras.—The etiology is unknown and the hemorrhagic diathesis is merely a part of the reactive symptom complex of some anaphylactic agent.

In this group the attacks recur at varying intervals with a free interval in between the attacks. The symptoms are various, fever, joint pains and swelling, urticaria, erythema, œdema, polyneuritis, albuminuria, hemorrhagic nephritis, colic, melena, etc. The occurrence of the various symptoms, the petechial eruptions, ecchymosis, etc., overlap and blend in the different forms and may exhibit their most marked symptoms in varying areas.

The blood platelets are slightly increased or very slightly below normal in

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number, the clotting time and the bleeding time are normal, and the blood clot contracts normally.

3. Idiopathic Purpura.—In this group he places those various forms of the hemorrhagic diatheses which are primary. The etiology is unknown. Without warning bleeding into the skin, from the mucous membranes, melena,

	Anaphylactic purpura.	Idiopathic purpura.
Etiology.	Known or suspected causative agent. Primary fever. Premonitory symptoms.	Unknown. No fever. No premonitory symptoms.
Premonitory symptoms.	Primary fever, urticaria, œdema, joint pains, hemorrhagic nephritis, colic, melena, etc.	None.
Bleeding time.	Normal.	Lengthened.
Clotting time.	Normal.	Normal.
Retraction of clot.	Normal.	Absent or markedly diminished.
Blood platelets.	Increased or slightly decreased.	Markedly decreased. May be absent during attack.

	Hæmophilia.	Idiopathic purpura.
Etiology.	Unknown.	Unknown.
History.	Classical history of bleeders in family involving males transmitted through female line.	No typical history. May have history of similar condition in the family but no definiteness in the transmission.
Cause of bleeding.	Traumatic.	Usually spontaneous, frequently multiple. Periodic with free interval. Trauma may cause bleeding but is not so definite as in hæmophilia.
Bleeding time.	Markedly lengthened.	Lengthened. Increased (especially during attacks).
Clotting time.	Markedly lengthened.	Normal.
Blood platelets.	Normal or increased in number.	Markedly decreased or absent during attacks.

hæmatemesis, nose bleed and hæmaturia occur. Fever is absent unless the case is otherwise complicated.

The characteristic features are, increased (lengthened) bleeding time, the absence of retraction of the blood clot or great diminution of this con-

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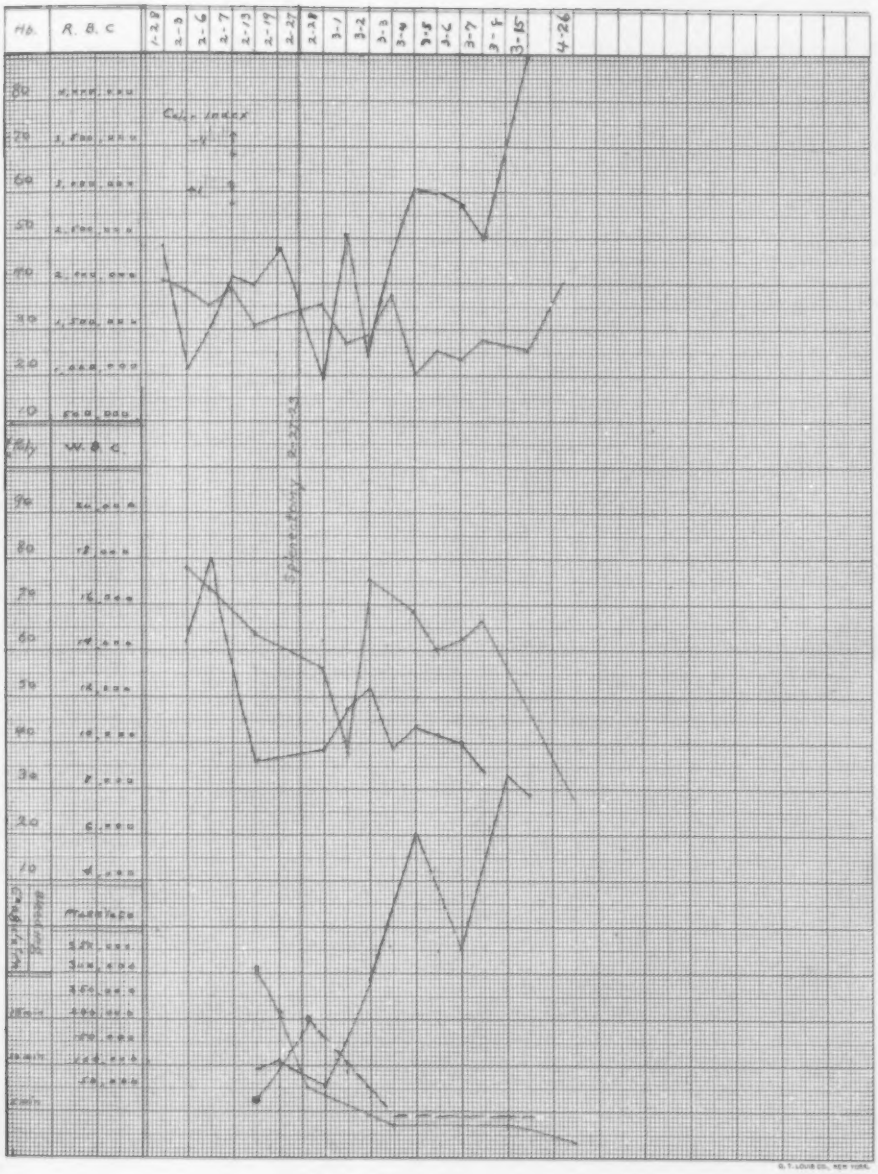

FIG. 1.—Platelets. — — — Bleeding time.

traction, marked diminution in the number of the blood platelets while the clotting time of the blood is normal.

Fonio gives the schematic forms for the differential diagnosis between anaphylactic purpura and idiopathic purpura, and hæmophilia and idiopathic purpura in the above table.

Kaznelson was struck by the observation of Frank, that in the conditions to which Frank had given the name "essentielle thrombopenie" there was a constant enlargement of the spleen, and formulated the hypothesis that the disease was due to some destructive agent which destroyed the blood platelets and that the spleen, because of its enlargement had some definite relationship to the process of platelet destruction. Acting on this hypothesis in October, 1916, he submitted a female patient of thirty-six who had had the characteristic features of the essential purpura, described by Hayem, Frank, and others, to splenectomy with remarkable results. The blood platelets which were 300 to 600 before operation rose rapidly to 600,000 on the second day after operation. The clot contracted early and the bleeding time diminished, nose bleed stopped and the menses became normal in character. He has had the patient under observation for three years and the improvement has been constant.

Since then Kaznelson has reported two other cases submitted to splenectomy with a satisfactory outcome. Schmidt, Minkowski, Ehrenberg, Keisman, Beneke, Cori have reported other similar cases in the German literature. In America, Bowen reports a satisfactory case from the Buffalo General Hospital and Brill showed two cases at the meeting of the Medical Section of the New York Academy of Medicine on February 15, 1923, submitted to splenectomy with a satisfactory outcome.

Case Report.—Esther C., eight years old, was admitted to the First Medical Division, Doctor Connor's service, on January 27, 1923 and discharged March 16, 1923.

Her present illness began two days before admission with almost constant bleeding from the nose and gums, and the appearance of red spots on the body. She has not vomited blood or passed blood in urine or stools.

Past History.—Patient was well up to three years ago, then had scarlet fever; she recovered and was well up to one year ago. At that time she began to have repeated nose bleeds which were difficult to stop, at intervals of every two or three weeks. One week ago she had a bronchopneumonia from which she is now convalescing.

Family History negative for family bleeding, two brothers and sister well.

Examination showed well nourished, pale child, with hemorrhagic spots on face. Bleeding from left nostril and gums. Heart, lungs, abdomen were negative. Examination of skin showed hemorrhagic areas over the entire body most marked over the lower extremities. In one area on the hip there was a large ecchymotic area resembling a bruise.

Clinical pathological report:

Red cells, 2,400,000—H. B. 40%, Color index 0.8.

White cells, 38,000—Polymorphonuclears 85%, Lymphocytes 11%, Large mononuclears 4%.
Platelets, 40,500.
Coagulation time 6 minutes.
Bleeding time more than 20 minutes.
Clot did not contract.
Fragility test—Hemolysis began at 0.45, complete at 0.36.
Temperature 99, Pulse 116, Respiration 26.
Chronological Course:
Day of admission 15 c.c. whole blood intramuscularly.
15 c.c. horse serum intramuscularly.

First day after admission.	Vomited blood.
Second day after admission.	Nose bleed for three hours, packing.
Third day after admission.	Nose bleed, slight, packing.
Fourth day after admission.	Transfusion 150 c.c. of blood intravenous (Unger method) followed by chill.
Fifth day after admission.	No bleeding since transfusion.
Sixth day after admission.	Bleeding from right nostril, packed.
Seventh day after admission.	Nose bleed, practically throughout day, partially stopped by packing. 15 c.c. horse serum intramuscularly.
Eighth day after admission.	Enema, large stool containing altered blood.
Ninth day after admission.	Nose bleed, hæmatemesis, transfusion 340 c.c. blood, followed by chill.
Tenth day after admission.	No bleeding.
Eleventh day after admission.	Melena, nose bleeds.
Twelfth day after admission.	Nose bleed not stopped by packing, cocaine, adrenalin, monochloracetic acid.
	Stopped with thromboplastin.
Fifteenth day after admission.	No bleeding, palpable spleen noted.
Sixteenth day after admission. Seventeenth day after admission.	Nose bleed slight.
Eighteenth day after admission.	Transfusion 250 c.c. followed by chill.
Nineteenth day after admission.	Severe hemorrhage from left nostril for five hours, vomited two pus basins of blood.
	Nose bleed all afternoon. Not controlled by packing.
Twentieth day after admission.	Melena, vomitted blood during day. Constant oozing from nostrils not stopped by thromboplastin.
Twenty-first day after admission. to Twenty-ninth day after admission.	No bleeding.
Thirtieth day after admission.	Profuse nose bleed, chills, much worse. Consultation with Dr. R. G. Stillman.

On February 27th, thirty-one days after her admission, at the suggestion of Dr. R. G. Stillman, of the First Medical Division, splenectomy was done through a left rectus incision and a somewhat enlarged spleen easily removed. No

hæmolymph-nodes were noted along the splenic vein. The liver and gall-bladder seemed normal. The blood was quite watery. Tier closure of the abdomen without drainage. The wound healed by primary union and the patient was sent to the country on the seventeenth post-operative day.

The essential features of the case following the splenectomy were the immediate cessation of the bleeding, the marked increase in the number of blood platelets from 50,000 to over 600,000, the change in the bleeding time from 15 to less than 5 minutes and the marked improvement in the condition of the child. This improvement has continued up to the last observation made on May 25, 1923.

The last observations on the blood made by Dr. Ralph G. Stillman on April 26, 1923 are as follows:

Bleeding time 2½ minutes. Hæmoglobin, 40%
Polymorphonuclears, 24.0%
Lymphocytes, 68.8%
L.M. and Tr., 4.0%
Eosinophiles, 2.4%
Normoblasts one to each 250 white cells.

Film shows leukocytosis, well marked pallor of red blood-cells. Some granular basophilia and slight polychromatophilia. There are abundant platelets, looks like a secondary anemia.

Pathological Report.—Esther C., May 16, 1923. Hyperplasia of the pulp. Myeloidization. Specimen consists of a spleen of normal contour, rather dark bluish-red color. Capsule elastic, not very tense. Weight with contained blood 120 grams. (Patient's weight 47.5 lbs. 21-590 kg.) Size 4 mm. x 5.5 x 11 mm. On section of capsule much blood escaped estimated at about 15 c.c. Piece removed sterile for culture. Sections placed in formalin, bichloride, Zenker and absolute alcohol. On section the cut surface is smooth, bright red and very thickly studded with follicles that appear of normal size. The consistence is firm, possibly slightly firmer than normal. There was no obvious increase in connective tissue. No hemorrhages were seen. Films made from surface.

Stained film shows the usual number of lymphocytes and large mononuclear cells. Polymorphonuclear leukocytes, neutrophiles are moderate. Eosinophile leukocytes are fairly numerous. There are many normoblasts and a few megaloblasts. There are also a moderate number of myelocytes. Most of them neutrophilic but a few eosinophilic and basophilic. From the cells found in these films one would expect to find in the spleen areas of myeloidization and possibly also of erythropoiesis.

On microscopic examination there appears to be no increase in the amount of fibrous tissue present. Lymphoid follicles all have large germinal centres, but are no larger than one would expect in the spleen in a child of this age. The arteries in the follicles show almost uniformly a thickening and hyalin degeneration of the wall and a narrowing of the lumen. The venous sinuses appear to be approximately normal in size. The pulp in places shows an increased blood content and a hyperplasia of the pulp cords. There are seen in the pulp occasional nucleated red cells and a moderate number of myelocytes. There are also a number of undifferentiated mononuclear cells whose exact nature is unknown. There appears to be a slight increase in the number of eosinophiles present. Collections of blood platelets were not recognized.

Bacteriological Report.—Doctor Wheeler. Cultures from the spleen were sterile.

CONCLUSION

The removal of the spleen has a definite effect in the idiopathic type of hemorrhagic purpura and this effect seems to be related in some way to the change in the bleeding time and in the number of the blood platelets.

LITERATURE

Minkowski, O.: Med. Klinik, December, 1919, vol. l, p. 1243.
Ehrenberg, Charlotte: Monatschr. f. Geburt und Gyn., 1920, vol. li, p. 99.
Keisman: Med. Klinik, 1921, No. 3, p. 74.
Kaznelson: Wien Klin. Wochenschir., 1916, No. 46, p. 1451.
Kaznelson: Zeitschr. f. klin. Med., 1919, vol. lxxxvii, p. 133.
Fonio: Zeitschr. f. klin. Med., 1920, vol. lxxxix, p. 77.
Cori, G.: Zeitschr. f. klin. Med., vol. xciv, p. 356.
Bowen, B. D.: Bull. Buffalo Gen. Hosp., 1923, vol. i, p. 92.
Hayem, G.: Lecons sur les Maladies du Sang., 1900, Masson and Cie.
Frank, E.: Berlin. Klin. Wochenschir, 1915, vol. lii, p. 454.
Schmidt: Berlin Klin. Wochenschir, 1917, p. 959.
Beneke, E.: Therap. d Gegenio., December, 1917, p. 418.

SPECIAL POINTS IN GALL-BLADDER SURGERY*

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The outstanding problems of gall-bladder surgery remain practically unchanged with the passing years. In this paper, therefore, I shall confine myself to a discussion of certain present opinions which are based upon the experience of my associates and myself in 1235 operations on the gall-bladder among which the records of 886 operations are available for detailed study.

Diagnosis.—As in the diagnosis of hyperthyroidism, of cancer of the stomach, of nephrolithiasis, of appendicitis, it is not the frank, typical case which challenges us, but the case with vague, disquieting, sometimes acute, often chronic symptoms which, while perhaps they simulate most closely those of a cholelithiasis or cholecystitis, may refer to the stomach, the kidneys, the appendix, or the pancreas. In some cases stones may be promptly and clearly defined by a röntgenogram, or the outline of a thickened enlarged gall-bladder may be visible. In others the diagnosis as far as the röntgenogram is concerned is based upon the presence of abnormalities in adjacent organs and in many cases series of plates are required. It has been our experience that our percentage of correct pre-operative diagnoses increases in direct relation to the amount of study which is devoted to the case by our röntgenologist.

As to the diagnostic value of the Lyon test, we agree with Fitz † of the Mayo Clinic that "it seems doubtful whether much diagnostic significance can be attached in the clinical study of cases to similar analyses of bile, the specimens of which are collected through the duodenal tube by Lyon's method, and at best by an indirect route from an undetermined source in the biliary tract."

Whatever diagnostic aids are utilized, however, and in uncertain cases these should include all the measures at our command, it should be emphasized that, as in the differential diagnosis of hyperthyroidism, or of appendicitis, final dependence must be placed upon clinical judgment.

In certain cases, however, despite the most complete history, despite a painstaking physical examination, despite the aid of the röntgenologist, despite chemical analyses, and even despite a direct examination through a right rectus incision, the correct interpretation is not made. The one final criterion, therefore, is the end-result.

Management.—The management of cases of gall-bladder disease, which includes the type of operation, is strictly individualized.

In general we have followed the lead of the Mayo Clinic as to cholecys-

* Read before the American Surgical Association, June 1, 1923.

† Fitz and Aldrich: Clinical Observations on Certain Constituents of the Bile. J. A. M. A., vol. lxxix, p. 2199, Dec., 1922.

tectomy, and it has been our experience that this method yields the higher percentage of post-operative symptom-free results; our changing opinion regarding the relative values of cholecystectomy and cholecystostomy is indicated by the fact that although our total statistics show that 43 per cent. of our series were cholecystectomies and 57 per cent. cholecystostomies, during the years 1917 to 1922 inclusive, this relation was reversed, 84 per cent. of the later series being cholecystectomies as opposed to 16 per cent. cholecystostomies.

Nevertheless in a certain group of cases, cholecystostomy bears a lesser mortality. Therefore, in patients with high blood-pressure and interstitial nephritis, in the aged and in obese patients, and in severely jaundiced patients, the lesser operation is performed.

In emaciated, jaundiced, depressed cases, a slow intermittent decompression by means of a fluid-tight drainage system is important. This manœuvre is comparable to that employed by urologists in cases in which the urinary bladder is distended.

In a jaundiced case in which the gall-bladder is a shrunken mass of scar tissue containing no bile, while the common duct is dilated, decompression is accomplished by drawing off most of the bile with a syringe, opening the duct to remove any stones which may be present in the immediate field, and establishing a fluid rubber tube drainage, with an abundance of gauze drainage just below the point of common duct drainage.

The point of prime importance in the case of a greatly depressed patient is the performance of the minimum amount of surgical trauma needed to establish drainage.

After the utmost possible degree of restoration has been accomplished by blood transfusion, hypodermoclysis, hot packs, rest, the further operative procedures may be performed with lessened danger. It should be borne in mind that morphine is contraindicated in these cases because of its specific depressing effect upon the liver.

In all operations upon the gall-bladder the control of infection is of paramount importance, of more importance, even, than in the case of operations within the pelvic cavity or in the lower abdomen, for within the upper abdomen the defense against infection is weaker than in the lower abdomen. Surprisingly active infection, therefore, may follow very slight soiling by the infected contents of the gall-bladder or ducts.

The best measures of prevention are an ample exposure and an adequate preliminary packing with gauze so complete that not a pad will be changed during the operation. Even when every possible precaution has been taken we occasionally encounter a leakage of bile. For this reason I still hesitate to close without drainage. In our experience a high Bevan incision serves best both for an ample exposure and for the post-operative restoration of a sound abdominal wall. In cases in which the condition of the patient demands the minimum primary operation, *i.e.*, the establishment of drainage and no more, a very short incision immediately over the gall-bladder and the insertion

of the drainage tube constitute almost a minor operation. In every case it is important to exercise the utmost care to prevent the slightest tear or cut into the liver substance. In an occasional case of prolonged severe jaundice associated with infection, a fatal hemorrhage may occur in spite of calcium and repeated blood transfusions. In one such case six donors were used, giving a total of 3800 c.c. of blood, and calcium was used before and after operation without avail.

Statistics.—It is difficult or impossible in this as in other fields satisfactorily to compare the statistics of many reporters because of the variations in the form of their presentation. The following figures culled from the literature, however, are of especial interest in their bearing upon the cholecystectomy *vs.* cholecystostomy controversy.

	Operative mortality		End results					
			Cholecystectomy			Cholecystostomy		
	Cholecystectomy	Cholecystostomy	Cured	Imp.	Not imp.	Cured	Imp.	Not imp.
Erdman, 1910.....	4.0%	4.2%						
Truesdale, 1921... (Exclusive of carc.)	2.3		89%	6%	5%	55%	32%	13%
Goodwin, 1921....	3.3%	5.0%	88%	9%	3%	71.5%	23%	5.2%
Homans, 1920....	5.3%		77%	19.4%	3.6%			
			(Good)	(Fair)	(Bad)	(Good)	(Fair)	(Bad)
Moore, 1921	5%	5%	70	20	10	40	45	15
Mayo, C. H., 1920.	Operative mortality, not divided as to type of case–2.2 to 2.4%		(Results not divided as to type of operation)					
			Cure 60%		Great imp. 30%		Less imp. 10%	

In our own series among a total of 1235 operations upon the gall-bladder and gall-ducts, the mortality rate has been: cholecystectomy, 2.5 per cent.; cholecystostomy, 5.4 per cent.

Although these figures make it appear that cholecystectomy is the safer operation, this is due to the fact that cholecystostomy is used in the "bad risk" cases.

SUMMARY

The points of prime importance in the surgical management of gall-bladder diseases may be briefly stated as follows:

1. Strict individualization of patient.
2. Restoration and maintenance of the internal respiration of the cells.
3. Decompression only, in extreme cases.
4. Special precautions against infection.
5. Drainage to prevent possibility of post-operative infection from leakage.
6. The criterion for choice between cholecystectomy and cholecystostomy is the condition of the patient.

THE MORTALITY FOLLOWING OPERATIONS ON THE LIVER, PANCREAS, AND BILIARY PASSAGES

A STATISTICAL STUDY

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This study concerns the mortality following operations at the Mayo Clinic during 1922, for diseases of the gall-bladder and associated viscera. The operations were performed by ten surgeons on the permanent staff of the Clinic in its hospitals. Many of the cases were ordinary uncomplicated disorders of the gall-bladder, while others were much more serious, as the infection had perforated the gall-bladder and invaded other tissues, or the flow of bile had been obstructed, with resultant biliary cirrhosis and complete jaundice. We were gratified to find, in comparison with former years, that the results were better.

Factors Tending to Diminish the Mortality Rate.—It is difficult to decide on the factors that contributed to the better results because there was no control from which to make comparative studies, but I am inclined to attribute the diminished mortality to several factors, and particularly, to the efficacy of the preparation of many of these patients before operation. It is interesting to note that, although more jaundiced patients have been operated on than in any previous year, the danger of post-operative bleeding has been practically eliminated; this undoubtedly is a factor in lowering the mortality. More accurate observation of the patient immediately following operation, and anticipating some of the serious complications, has, I believe, proved a factor in the better results.

The operative technic is practically the same now as in former years, except that the amount of drainage used in the operative field has been reduced; whereas it was formerly believed to be necessary to use a considerable amount of gauze and rubber tissue and rubber tubes for drainage, it is now considered much safer to reduce the drainage material to a minimum, and in the clean cases in which the technic has been accurately carried out it is better to close the abdominal wound without drainage. Drainage has not been dispensed with in cases in the Clinic in which it was necessary to open the common duct.

Experience and better judgment may be regarded as factors which tended to attain the results of 1922. In Table I we have tabulated the causes of death of eleven patients operated on. This is interesting because it shows the proportion of patients who present themselves too late for any form of treatment, and also approximates the proportions of patients with primary

cancer of the pancreas for which very little can be done. These patients were all moribund or nearly so on admittance, and surgical treatment could not avail.

TABLE I.

PRINCIPAL CAUSES OF DEATH OF PATIENTS NOT OPERATED ON.

Suppurative cholecystitis	1
Choledocholithiasis	1
Cirrhosis of the liver	1
Carcinoma of the gall-bladder	1
Carcinoma of the liver	1
Carcinoma of the pancreas	6

OPERATIONS ON THE LIVER

In Table II is a list of the twenty-two cases in which an operation for primary disease of the liver was performed. The largest single group of cases proved to be cancers of the liver. Undoubtedly most of these cancers were secondary, but the explorations seemed to be legitimate, and the clinical

TABLE II.

MORTALITY FOLLOWING OPERATIONS ON THE LIVER.

	Cases	Deaths	Cause of death
Abscess: Drainage	2		
Carcinoma: Exploration (excision of specimen)	8	1	Pneumonia; necropsy refused.
Cirrhosis: Talma-Morrison operation	1		
Exploration	5		
Cyst: Drainage	2		
Excision	2		
Prolapse: Hepatopexy	1		
Infectious hepatitis with jaundice: Cholecystostomy	1		

histories and physical examinations indicated a reasonable prospect for improvement following operation. Had the condition been known before operation, exploration would not have been made, but it seems impossible to establish the inoperability of certain cases without exploration. One patient died after exploration which revealed an extensive cancer of the liver; this

is a demonstration of the serious risk attending this type of operation. Necropsy was not obtained in this case and the death is ascribed to possible pneumonia.

There were six cases of cirrhosis of the liver, but in only one did the Talma-Morrison operation appear to be suitable. In the presence of jaundice and a large amount of ascites the Talma-Morrison operation has not been very satisfactory, while in cases in which there is no jaundice and the quantity of ascites is not too great, or the liver too badly diseased, this plan of transferring the circulation has seemed to accomplish a greaf deal.

OPERATIONS FOR UNUSUAL CONDITIONS OF THE GALL-BLADDER

In Table III are listed cases of unusual disorders of the gall-bladder and ducts. There was one case of acute perforation of the gall-bladder, and also

TABLE III.

MORTALITY FOLLOWING OPERATIONS FOR UNUSUAL CONDITIONS OF THE GALL-BLADDER AND DUCTS.

	Operations	Deaths	Cause of death
Acute perforation of cystic duct	1		
Acute perforation of gall-bladder: Cholecystostomy	1		
Carcinoma of ampulla of Vater: Choledochostomy	1		
Resection of ampulla: Cholecystostomy, choledochoduodenostomy	1	1	Hemorrhage and hepatic insufficiency.
Carcinoma: Exploration	7		
Cholecystectomy	2	1	Peritonitis; necropsy refused.

one in which a perforation occurred in the cystic duct. Operation was performed early with recovery in both cases. Acute perforation of the gall-bladder, or of the bile ducts, with the pouring of bile or stones and pus into the general abdominal cavity has occurred very rarely. On the other hand, cases are often seen in which there has been a small perforation with a slight amount of leakage and a local abscess well walled off, and quite often cases have been encountered in which a perforation has extended into the duodenum, stomach, or colon. Some years ago I reported a case of perforation of the common duct and a large amount of bile free in the abdomen; no similar case has since been observed in the Clinic. Acute perforation of the gall-bladder occurs, as a rule, in only one of several hundred cases of cholecystitis.

In the series of cases of diseases of the gall-bladder and ducts were two of carcinoma of the ampulla of Vater.

In one case a man, aged seventy years, had been operated on elsewhere three years before for cholecystitis, and the gall-bladder had been removed. He said that he was jaundiced when he was operated on. He recovered very quickly, the jaundice soon disappeared, and he remained well until three months before presenting himself at the Clinic for examination. His chief and only complaint at that time was a painless jaundice with slight loss of weight and strength. The jaundice had appeared three months before and had persisted but fluctuated in intensity. At operation the liver revealed definite biliary cirrhosis and the common duct was greatly dilated; the pancreas seemed normal, but the neoplasm could be readily made out in the ampulla. The common duct was opened with a small incision, and a rather thin colorless fluid, which was under tension, escaped. Without allowing all of this fluid to escape at once with the possibilty of sudden production of a negative pressure in the ducts of the liver, a small tube was stitched into the opening in the duct, and by keeping the tube closed by a clamp part of the time, the liver was gradually decompressed. Whether or not this was of any avail, is doubtful, but there was no reaction following the procedure. Drainage from the tube became bile-stained in a few hours, and normal-looking bile appeared in a short time. The patient recovered completely. Because of his age and the fact that he was quite contented with the tube and opposed to further operating, he was dismissed with the tube draining his common duct. He has remained well thus far, seven months after the operation.

In the second case of cancer of the ampulla, the patient was a man aged fifty-five years, who was in extremely bad condition because of deep jaundice which had existed for several months. After careful preparation by calcium given intravenously, an exploration was made under local anæsthesia and revealed extensive biliary cirrhosis with gall-bladder and ducts greatly distended. When the gall-bladder and ducts were emptied, the neoplasm could be palpated at the ampulla. It seemed best to establish biliary drainage by inserting a tube into the gall-bladder and waiting for a return of normal activity of the liver with improvement in the general condition before resecting the ampulla. Bile drained rather freely. At the end of three months, resection of the ampulla was performed without the usual preparation. It was found that some interference still existed with the biliary flow and that the biliary cirrhosis still persisted. A resection was made, but the patient died from insufficiency of the liver and hemorrhage from all surfaces. If it could have been recognized before the second operation, that there was still some biliary cirrhosis in spite of the fact that there was no apparent jaundice, by preparing the patient in the usual manner, I believe the result obtained might have been different.

Cancer of the gall-bladder was found in nine cases. In seven, it was too extensive for radical removal. In two cases the gall-bladder was removed; one of the patients died. If this case had been recognized as cancer before beginning the cholecystectomy, removal would not have been attempted.

There was a history of colic lasting twenty-one years. A chronic infection was believed to be present until the operation had been carried too far to be stopped. Part of the duodenum had to be resected and a very extensive operation carried out. Death occurred on the fourth day, probably from peritonitis. When carcinoma occurs in the gall-bladder, it is usually in cases in which gall-stones have existed for a long time. Not many radical operations for this condition have resulted in cure.

In Table IV are tabulated the results of operations for cholecystitis. Forty-five cholecystectomies were performed for acute cholecystitis with no deaths, and twenty-two cholecystostomies with one death. The grading of acute or

TABLE IV.

MORTALITY FOLLOWING OPERATIONS FOR CHOLECYSTITIS.

	Operations	Deaths	Cause of death
Cholecystitis, acute, with or without stones			
Cholecystectomy	45		
Cholecystostomy	22	1	Hepatic insufficiency
Cholecystitis, chronic, with or without stones			Peritonitis, 5; pneumonia, 3; dilatation of stomach, 1.
Cholecystectomy	890	11	Pulmonary embolism 2.
Cholecystostomy and partial cholecystectomy	1		
Cholecystostomy	45	2	Peritonitis. Liver insufficiency, 1.
Exploration	1		
Exploratory choledochotomy	31		
Cholecystitis, chronic, with stones in the gall-bladder and common duct: Cholecystocholedochotomy	1		
Cholecystitis, chronic, with stones and biliary fistula: Cholecystectomy; dissection of the fistulous tract	2	1	Peritonitis, empyema.
Cholecystostomy	1		
Cholecystitis, chronic, with stones; retroversion of the uterus; appendicitis: Cholecystectomy; intraperitoneal shortening round ligaments, appendectomy	1	1	Pulmonary œdema.
Cholecystitis, chronic, with stones, duodenal ulcer and chronic appendicitis: Cholecystectomy, posterior gastroenterostomy, appendectomy	10	1	Peritonitis.
Cholecystitis, chronic, with stones, postoperative ventral hernia: Cholecystectomy; herniotomy	12	1	Peritonitis; fat embolism.

chronic inflammation in the gall-bladder, was made by the pathologist as he examined the tissue: The one death followed a drainage operation. The patient had been very sick for many weeks with an infected gall-bladder without signs of jaundice. It seemed best to operate as little as possible, and to

establish drainage, with the idea of removing the gall-bladder and examining the ducts at another time if there was further trouble. Free drainage followed the opening of the gall-bladder and removal of stones, but without reaction, and death occurred on the fifty-second day. Necropsy revealed infection of the liver and a stone in the common duct. We had suspected the presence of a stone, but the patient's condition did not warrant exploration. It has been our experience often that when such patients do not improve, a common duct stone may be present even though there is no evidence of jaundice.

There were eleven deaths in 890 cholecystectomies for chronic inflammation in the gall-bladder. Five of the patients died from peritonitis; one of these did not come to necropsy. One patient with a serious cardiac disorder died a cardiac death. Three died from pneumonia. Dilatation of the stomach was recorded in one case, since nothing else could be found to account for the death. However, this condition existed at the time of the operation. Two of the patients died from pulmonary embolism. Many of the patients were obese. In some instances their weight had been reduced before the operation. It is questionable whether an obese patient is any better, or as good a surgical risk after a sudden loss of weight, as he is normally. It would seem that there should be no deaths following operations for chronic disease of the gall-bladder, yet it is very unlikely that we shall ever be able to operate in a very large series of these cases without some serious consequences.

ABSTRACT OF THIRTEEN CASES IN WHICH OPERATION WAS FATAL

CASE I.—R., a man aged forty-five years, an alcoholic, had had subacute cholecystitis with stones and hydrops. Operation under nitrous oxide and ether was performed and the gall-bladder was found to be buried in the liver. Two gauze strips and one tube were inserted because of oozing after the gall-bladder had been removed. These drains were removed the third and the fourth day. respectively, resulting in bile drainage. Evidence of toxæmia was manifested soon after operation. Death occurred on the eleventh day from peritonitis.

CASE II.—M. P., a woman aged fifty-three years, was in good general condition. Cholecystitis with stones, and pancreatitis were found. Cholecystectomy and appendectomy were performed. On the third day there was vomiting and the pulse became irregular. Death from peritonitis resulted on the seventh day. There was a subphrenic abscess, but no bile in the abdomen. The wound was closed without a drain.

CASE III.—R. S., a man aged thirty-nine years, came to the Clinic in fair general condition. He had lost twenty-six pounds in weight, and his blood-pressure was low. At operation appendicitis and slight cholecystitis were revealed. The gall-bladder and appendix were removed. The abdomen was closed without drainage. The patient died the fourth day. Necropsy revealed early peritonitis, 300 c.c. of blood, and bronchopneumonia, but no bile in the abdomen.

CASE IV.—J. P., a man, aged twenty-eight years, was in good general condition. His blood-pressure was low. The history and findings were indefinite. A cholecystectomy was performed under difficulties. Chronic inflammation in the gall-bladder and adhesions were found, but no stones were present. A drain was not inserted. Death occurred on the fourth day from peritonitis.

CASE V.—M. U., a woman, aged sixty-seven years, was very obese. She had fatty myocarditis and much pain and infection. Cholecystostomy was attempted

without success, and the gall-bladder had to be removed. There was a temporary cardiac reaction. The patient died the tenth day. Necropsy revealed peritonitis and marked arteriosclerosis. There were no clinical signs of peritonitis and the patient died a cardiac death.

CASE VI.—T. S., a man, aged fifty-four years, weighed 210 pounds. Before operation his weight was reduced eighteen pounds. It was difficult to expose the gall-bladder which was much infected and contained many stones; the gall-bladder was removed with only a slight amount of soiling. The wound was closed without a drain. Influenza developed within a few hours after operation and death ensued in less than forty-eight hours. Necropsy was not performed.

CASE VII.—F. A., a man, aged sixty-one years, had had arteriosclerosis and emphysema. His heart sounds were not clear. He had suffered from abdominal attacks and had been unable to care for himself. The operation revealed much infection in the gall-bladder and appendix, both of which were removed. Two strips of gauze and one tube were used as a drain. The patient did well for forty-eight hours, then showed all signs of pneumonia, and died on the sixth day.

CASE VIII.—B. DeJ., a man, aged thirty-nine years, had been in good general condition, but had lost twenty-two pounds in a few months. The appendix, and the gall-bladder which contained stones, were removed. A tube and gauze drain was used. Coughing and signs of pneumonia developed on the third day; on the tenth day the wound opened and had to be resutured. No signs of peritonitis resulted, but the pneumonia progressed, and the patient died on the twenty-second day.

CASE IX.—R. H. J., a woman, aged twenty-seven years, came to the Clinic with symptoms simulating subacute perforation. At operation many adhesions were found around the gall-bladder, but no ulcer. The gall-bladder was removed and one tube drain inserted. The patient died on the third day, seemingly of respiratory failure. Necropsy revealed splanchnoptosis with general hypoplasia, œdema of the liver, and cloudy swelling of the kidneys.

CASE X.—P. G., a woman, aged fifty-six years, had been in fair general condition except for severe gall-bladder attacks, and marked varicosity of the veins in the right leg. Empyema of the gall-bladder was revealed at operation. The gall-bladder and appendix were removed, and a gauze and rubber drain was used. There was some tachycardia on the third and fourth days after operation. The patient was up on the eleventh day, but died while sitting up on the twelfth day. The wound had healed. Necropsy revealed pulmonary embolism.

CASE XI.—F. W. M., a woman, aged forty-nine years, had been in fair general condition. Dilatation and curettement were performed, a specimen was removed, and the cervix repaired. The gall-bladder, which contained no stones, and the appendix were removed. Recovery was uneventful. The wound healed, but sudden cyanosis and death occurred after the patient had been up. Necropsy was not performed.

Removal of the gall-bladder has been the operation of choice, but for special reasons drainage operations were performed on forty-five patients, two of whom died.

CASE XII.—S. P., a man aged fifty-six years, in good general condition, had had colics for one year. The gall-bladder was empyematous and difficult to remove. One dressed tube and gauze were inserted, and the gall-bladder was drained. The patient became jaundiced and died on the sixth day, probably from peritonitis. Necropsy was not performed.

CASE XIII.—W. R. H., a man aged sixty-two years, had a splenectomy for Banti's disease six weeks before, when gall-stones and advanced portal cirrhosis

were discovered. The gall-stones were removed and the gall-bladder was drained. The patient died on the seventh day, probably from portal cirrhosis. There was some thrombosis of the splenic vein.

The last three deaths referred to in Table IV show the seriousness of too much operating at one time. It cannot be said that the result would have been better if the cases had been handled differently, but as a rule it is probably more advisable to operate in two stages than do too much at one time. This applies especially when more than one incision is necessary; usually it is not best to operate in the pelvis and in the upper abdomen at the same time.

TABLE V.

MORTALITY FOLLOWING OPERATION ON THE GALL-BLADDER AND ON COMMON DUCT.

	Operations	Deaths	Cause of death
Stones in the gall-bladder or bile ducts.....			Liver insufficiency, 1.
Choledochostomy.....	25	2	Peritonitis, 1.
Choledochostomy and cholecystectomy..	66	1	Liver insufficiency.
Choledochostomy and cholecystostomy..	23	1	Pneumonia.
Cholangitis with choledocholithiasis: Choledocholithotomy.....	1		
Cholangitis: Choledochostomy.....	4		
Diverticulum cystic duct: Excision.....	2		
Fistula, cholecystoduodenal: Closure.....	5		
Fistula or stricture common duct: Cholecystoduodenostomy.....	1		
Choledochostomy.....	1	1	Liver insufficiency.
Drainage fistula.....	1		
Excision fistulous tract.....	2		
Hepatico-duodenostomy or reconstruction of common duct.....	12	3	Shock, 1; hemorrhage, 1; hepatic insufficiency, 1.
	143	8	

In Table V are listed operations on the common duct. Besides these the common duct was explored in thirty-one cases in which the gall-bladder was removed. The exploration was made because the duct was greatly enlarged, or because a stone was suspected, or could not be ruled out. It is interesting to note that of the four deaths in 150 operations on the common duct (Tables IV and V), not one resulted from hemorrhage, in spite of the fact that many of the patients were deeply jaundiced at the time of operation. All of these jaundiced patients were given careful preparatory treatment, as outlined by Walters,[1] and undoubtedly this is the reason many of them did not bleed.

[1] Walters, W. W.: Pre-operative Preparation of Patients With Obstructive Jaundice. Surg., Gynec. and Obst., 1921, vol. xxxiii, pp. 651–656.

ABSTRACT OF FOUR CASES IN WHICH OPERATION WAS FATAL

CASE XIV.—G. B. B., a woman, aged sixty-one years, had been operated on twice before, once for drainage of the gall-bladder and later for removal of it. She had had disease of the gall-bladder for forty-five years, and had lost forty pounds. She had had fluctuating jaundice, which was sometimes very deep, but was clearing up at the time of examination. Her blood coagulation time was three minutes. At operation stones were removed from the thick, infected duct. Drainage of bile gradually decreased. Convalescence was good for five days, then all the symptoms of insufficiency of the liver developed. Necropsy revealed atrophy of the liver and kidneys.

CASE XV.—J. W. K., a man, aged sixty-three years, had had his gall-bladder removed two years before, with relief for six months. Since then he had had attacks of distress and jaundice. At operation a stone was removed from the common duct. No suture was required to close the duct, and a Penrose drain was inserted down to the opening. There was no jaundice at the time of the operation. The patient died of peritonitis on the fourth day. There was considerable bile in the peritoneum.

CASE XVI.—C. W., a woman, aged sixty-three years, had been operated on at the Clinic ten years before, for stones in the common duct and gall-bladder. The stones had been removed and drainage instituted. The patient had been well for a few years and then similar attacks had recurred. The duct was dilated, but no stone was found in it; one may have been pushed through. A cholecystectomy and choledochostomy were performed; bile drained freely. Two Penrose drains were inserted. The patient left the hospital on the eighteenth day, but did not gain afterwards, and died on the twenty-eighth day from asthenia and hepatic insufficiency. Necropsy was refused.

CASE XVII.—T. D., a man, aged sixty-three years, had had attacks of pain with jaundice, and had lost twenty pounds. He had jaundice 3, and low blood-pressure at the time of examination, and his blood coagulation time was seven minutes. He was prepared with calcium. At operation the gall-bladder and duct were drained, and a stone removed from the hepatic duct and much bile escaped. The patient died of pneumonia on the eighth day. There was a calculus in the duct, but apparently was not a factor in death as the patient had had a definite pneumonia for several days.

HEPATICODUODENOSTOMIES WITH RECONSTRUCTION OF THE COMMON DUCT

Following twelve hepaticoduodenostomies with reconstruction of the common duct, there were three deaths, one due to shock, one to hemorrhage, and one to hepatic insufficiency. Operations of this type are extremely difficult and often must be performed on deeply jaundiced and otherwise incapacitated patients. A few cases of "liver-shock" have been observed. Possibly because of the sudden release of pressure in the common duct, the reaction in the liver may result in shock. One of the deaths from this condition occurred a few hours after a not unusually difficult operation in which very little blood was lost, and not enough trauma produced to cause shock.

ABSTRACT OF THREE CASES IN WHICH OPERATION WAS FATAL

CASE XVIII.—C. Z. W., a woman, aged forty years, had had her gall-bladder removed elsewhere. Since then she had had no pain, but nausea, vomiting, and very deep, but painless jaundice. Operation revealed no common duct. The patient was in a very bad condition, and there was oozing from the wound. There

was no bile in the ducts. The patient was prepared by the use of calcium. She died on the fourth day. Necropsy was not permitted but it seemed to be a case of hepatic insufficiency.

CASE XIX.—G. W., a woman, aged fifty-seven years, had been operated on at home and her gall-bladder had been removed. She came to the Clinic deeply jaundiced, and was in poor condition. Operation then revealed much infection in the old operative field, and drainage only was made. The jaundice cleared completely and the patient was allowed to go home. She returned one year later, greatly emaciated and jaundiced. A very difficult operation for stricture was performed. The bleeding at the time of operation apparently continued; the patient died the same day from insufficiency of the liver and hemorrhage.

CASE XX.—H. U., a man, aged thirty-one years, had been operated on elsewhere four months before for gall-stones, and cholecystectomy had been per-

TABLE VI.

MORTALITY FOLLOWING OPERATIONS FOR OBSTRUCTIVE JAUNDICE.

	Operations	Deaths	Cause of death
Obstructive jaundice: Cholecystostomy	1	1	
Cholecystoduodenostomy	1		
Cholecystogastrostomy	1		
Choledochostomy	6	1	Pneumonia.
Obstructive jaundice with contracture of hepaticoduodenostomy opening: Enlargement hepatico-duodenostomy	1		
Obstruction of the common duct (post-operative): Incision and drainage of abdominal wall	1		
Tuberculosis of the hepatic duct with obstruction: Exploration	1		

formed; a biliary fistula had existed since six days after the operation. Much loss in weight had resulted (from 15 to 20 pounds). Operation revealed absence of the lower part of the duct. The hepatic duct was anastomosed to the duodenum. Shock was immediately evident after the operation in spite of there being no jaundice and no loss of blood. The patient died in twenty hours. Necropsy revealed no cause for the death.

In Table VI are listed twelve cases of obstructive jaundice. In nine of these, the gall-bladder was anastomosed to the stomach or duodenum, or the common duct or gall-bladder was drained, and nothing further attempted; two of the nine patients died. Those with drainage of the common duct had been operated on several times before, and were completely jaundiced at the time. Drainage of bile was established with difficulty and never was free.

In Table VII is a list of patients operated on during 1922, for pancreatic diseases. Two of the twenty-four died. One of these was operated on for cancer of the pancreas, producing deep jaundice. The gall-bladder was anastomosed to the duodenum; death resulted from pneumonia two weeks later.

TABLE VII.

MORTALITY FOLLOWING OPERATIONS FOR DISORDERS OF THE PANCREAS.

	Operations	Deaths	Cause of death
Carcinoma: Cholecystoduodenostomy	1	1	Pneumonia.
Exploration (excision specimen)	8		
Enterostomy	1		
Cyst: Exploration, drainage	6		
Excision	1		
Excision, partial, and drainage	1		
Fistula, recurring following drainage pancreatic cyst: Dilatation sinus tract	1		
Pancreatitis, chronic: Cholecystostomy	1		
Exploration	3		
Pancreatitis, acute hemorrhagic: Exploration	1	1	Acute pancreatitis.

Palliative operations of this kind are often worth while even in cases of fairly extensive malignancy; in others, it is impossible to know before operation that the disease is malignant, and possibility of cure justifies the procedure. Fortunately, we had only one case of acute hemorrhagic pancreatitis. The condition was serious at the time of the operation, and the patient died on the second day. Diffuse, acute pancreatitis is one of the most serious abdominal conditions with which we have to deal.

FURTHER OBSERVATIONS ON THE USE OF THE CAUTERY IN PEPTIC ULCER *

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In 1914, I proposed the use of the cautery for the excision of certain types of peptic ulcer. Since then we have employed the cautery in 725 cases of peptic ulcer. This experience has shown us the types of ulcers to which the cautery is most applicable, the contraindications to its use, the most effective way of utilizing it, the risk of the operation, and its end results. It is upon these points that this series of 725 cases will be reviewed.

Gastric ulcers may, for our purpose here, be arbitrarily divided into three groups: (1) those in which the crater is 1 cm. or less in diameter, (2) those between 1 and 2 cm., and (2) those over 2 cm. The cautery was first suggested for the first group, since it was commonly observed that, after knife excision of such small lesions, the remaining opening was out of all proportion in size to the lesion removed, and it seemed that some method might be devised to avoid this disadvantage. Ninety per cent. of all gastric ulcers involve the lesser curvature, and since a large percentage are small, the cautery has a wide applicability.

The method originally proposed for cautery excision of these small ulcers has been followed; that is, reflection of the gastrohepatic omentum exposing the peritoneal aspect of the ulcer, and accurate location of the crater of the ulcer by palpation, the perforation of the centre of the crater by a Pacquelin, or electric cautery, continuing the burning until the crater is completely destroyed, closing the opening by chromic catgut sutures, and following this procedure with a gastro-enterostomy. The opening to be closed is, therefore, not larger than the crater itself, it is closed with ease, and in the entire series of cases there has been no evidence of leakage. The success of the operation is, of course, dependent on the accurate localization of the crater of the ulcer, and it should be emphasized that the crater of the so-called lesser curvature ulcer is seldom on the lesser curvature; it is usually on the posterior wall.

Ulcers with medium-sized craters, that is, between 1 and 2 cm. in diameter, may be malignant without visible evidence. Because of this possibility, the crater should be exposed to view by opening the stomach, and an excision made by the cautery knife, as suggested by Sistrunk. The portion of the stomach containing the ulcer is first mobilized, the gastrohepatic omentum is dissected free, the site of the ulcer encircled and marked by traction forceps, and the crater accurately palpated. At the edge of the crater an incision is made. The crater of the ulcer in its situation on the posterior wall of the stomach is then

* Read before the American Surgical Association, June 1, 1923.

visualized, excised with the cautery knife, the opening closed in an antero-posterior direction, and the suture line covered by the peritoneal flap. The operation is completed by a gastro-enterostomy. When ulcers of this size, between 1 and 2 cm., are near the pyloric end of the stomach and can easily be mobilized, partial gastrectomy is the operation of choice, but if they are distant from the pylorus, our experience thus far has been that local excision by the cautery and a gastro-enterostomy give such excellent results with such a small operative mortality that one hesitates to employ an operation of distinctly greater risk. Cautery excision combined with gastro-enterostomy has been performed in the Clinic in 329 cases of gastric ulcer with an operative mortality of 2.12 per cent., a lower mortality rate than has been associated with any other type of operation performed for gastric ulcer in the Clinic. In one series of 148 consecutive cases, there was no operative mortality. Eighty per cent. of the patients report satisfactory results from the operation. Fourteen per cent. are only slightly improved, 4 per cent. failed to derive any relief, and 1.1 per cent. are known to have developed ulcers subsequently.

Ulcers over 2 cm. in diameter, as shown by MacCarty, should be regarded as malignant or potentially malignant. Partial gastrectomy is unquestionably justified in these cases, gastro-intestinal continuity being reëstablished by whatever method best meets the individual case. These large ulcers may, however, be in such a difficult situation that resection is not warranted. For example, large ulcers high on the lesser curvature, while not suitable for resection, may be thoroughly cauterized with little risk. We have dealt with a number of such cases in this manner with surprisingly good results, even when a gastro-enterostomy has not been performed at the same time. In some, excision of the ulcer with the cautery (which may have been only partial) has been combined with jejunostomy, as suggested by Moynihan, and catheter feeding continued until healing has taken place. I believe there is a larger field for this operation than we have realized, and that Moynihan has drawn our attention to a very useful method of dealing with these awkwardly situated ulcers.

In the series of 725 cases of peptic ulcer in which cautery excision was performed there have been 1.1 per cent. of recurrence of ulcers, including gastrojejunal. There is apparently no greater tendency for an ulcer to recur at the point of excision (providing, of course, that the ulcer has been satisfactorily excised) than at any other part of the stomach. The fact that, in 725 cases we have seen no evidence of a tendency for an ulcer to develop at the point of excision would disprove any theory, or fear, that the cautery, of itself, may give rise to ulcer. Mann has demonstrated that, after extensive excision of the gastric wall by the cautery, healing was so perfect that it was impossible to detect where the excision had been made, and we have observed in patients operated on for other conditions at various intervals after such excision, that the same perfect healing has taken place. This small percentage of recurrences of ulcer following local excision and gastro-enterostomy is not

of itself an argument for routine gastrectomy in gastric ulcer. Moreover, if recurrence of ulcer does take place, resection of the pyloric end of the stomach can be performed. The resection can then be regarded as the second stage of an operation, which is often advantageously carried out in two stages, namely, partial gastrectomy.

In a previous paper, I have shown that the relatively high subsequent death rate in patients operated on for gastric ulcer, in comparison with the normal subsequent death rate following operations for duodenal ulcer, was due to gastric cancer. Cancer may, and does develop after any operation for gastric ulcer, from a gastro-enterostomy to partial gastrectomy, but almost all cancers develop in those cases in which the lesion was not removed, and, judging by the early death from cancer following operation, malignancy existed at the time of the operation. In 418 cautery excisions for gastric ulcer, eight patients (1.9 per cent.) have subsequently died of cancer of the stomach, but this group includes those cases of inaccessible ulcer in which it could not be completely excised, and the earlier cases in which we were not familiar with the most effective manner of using the cautery. Furthermore, the incidence of cancer of the stomach in 418 persons of similar age (average forty-five years) in the general population is about 0.3 per cent. Our results indicate, therefore, that when a non-malignant gastric ulcer is satisfactorily excised and gastro-enterostomy performed, the incidence of gastric cancer following the operation is little more than it is in the general population.

The cautery is a useful adjunct in the management of ulcers on the posterior wall of the stomach, particularly when they are adherent to the pancreas. In these cases it is necessary, in order to secure good end-results, to separate the stomach from the pancreas; the edges of the opening are then excised with the cautery, and the area on the pancreas thoroughly seared.

Duodenal Ulcer.—In cases of duodenal ulcer we have not the same indications for excision, for while the excision of gastric ulcers is imperative, the excision of duodenal ulcers is not, because of the liability to cancer degeneration in the former and the absence of it in the latter. There are, however, two types of cases in which excision may be considered, small ulcers of the anterior wall with little scar formation, and ulcers which have been the cause of bleeding. The first group, that is, small duodenal ulcers of the anterior wall, may be safely removed by puncture with the cautery, the opening closed, and a gastro-enterostomy performed. The mortality rate following such operations will be under 1 per cent., and the end-results will be excellent in 85 per cent. of the cases. In the uncomplicated case, however, these results do not show any clear advantage over gastro-enterostomy.

Bleeding Type of Ulcer.—Experience has shown that an ulcer which has been the cause of bleeding may again bleed if it is not excised. I found that, if the ulcer was not excised in cases in which there was a history of hemorrhage before operation, 13 per cent. of the patients had hemorrhages after operation, even though all other symptoms have been completely

relieved. Therefore, particular efforts were made to excise all ulcers in such cases, whether in the duodenum or stomach. As there are sufficient reasons for the routine excision of gastric ulcer, other than a history of bleeding, this practice has not given rise to any new problems in the surgery of gastric ulcer, but it has in the surgery of duodenal ulcer.

The common location for duodenal ulcers, whether or not they have been complicated by hemorrhage, is on the anterior wall of the duodenum, and fortunately in this situation they can easily be excised either by cautery or knife. Multiple duodenal ulcers are found in 5.13 per cent. of cases, and this fact should be kept in mind when dealing with the bleeding type of ulcer.

Careful exploration, first by palpation, followed by inspection of the anterior wall through the opening made by the excision of the ulcer, is imperative under such circumstances, and will not infrequently reveal unsuspected lesions in some other portion of the duodenum, usually the posterior wall. Resection of the duodenum may be necessary to remove satisfactorily one or more ulcers; the incidence of subsequent hemorrhage, when such bleeding ulcers, whether gastric or duodenal, are radically dealt with, has been reduced more than one-half. Hemorrhages may recur, however, even after careful exploration and radical excision of all lesions, and it is then probable, unless new ulceration has occurred, that the hemorrhages are dependent on causes extrinsic to the stomach, operating through the liver.

The cautery is valuable in its applications to three groups of cases (1) small gastric ulcers in any situation, (2) ulcers of any size in a situation of difficult accessibility, and (3) bleeding gastric or duodenal ulcers.

CANCER OF THE COLON*

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The activities of the American Society for the Prevention of Cancer and allied groups, have tended in a way to centre the interest of the profession and of the lay public as well upon superficial cancers. There can be no doubt that this educational campaign has resulted in great improvement in the general situation, for persons afflicted with malignant disease of the mouth, the skin, or the breast are today seeking advice much earlier than formerly, and in addition many doubtful conditions proven on close study to be benign are coming to observation; in a general way the idea that it is best to seek help early seems to be slowly making progress, against the hitherto prevailing sentiment of the lay public to conceal such afflictions. Cancers of superficial situation of course form the most favorable group for this educational type of attack, since they are usually obvious and the patient's attention is attracted early in the disease. A different problem, however, is presented by deeply situated cancers, for, rather than the growth itself, it is commonly the secondary effects of the growth which attract attention, and these are not infrequently so insidious in onset and development that the patient fails to appreciate their significance until too late. It is not uncommon to find that the secondary effects, that is to say, the symptoms, of a deeply situated cancer have been regarded so lightly by the patient that the physician's diagnosis of cancer quite fails to convince the sufferer of the seriousness of his malady. Pain is, unfortunately, not a symptom in the early stages of malignant growth. Pain is a late sign and due not to the growth itself but to the secondary effects of the growth; in gastro-intestinal cancers pain is perhaps most frequently due to infection, which does not occur until the surface has been broken, and even then with an open lesion severe acute pain is not the rule. As a corollary, cancers of the gastro-intestinal tract usually cause the patients to seek help because of things other than pain; but when a cancer has been present long enough to cause these things—as, for instance, a tumor, loss of weight and strength, or anæmia—there is but little chance of cure. The percentage of cures of cancer of the stomach or of the rectum is very low. There is a rather general opinion that cancers of the gastro-intestinal tract which produce obstruction are favorable as compared to those which do not produce obstruction, since this feature forces the patient to seek advice. Cancer of the colon is commonly thought of

* Read before the American Surgical Association, May 31, 1923.

as a tumor prone to produce obstruction. We find furthermore a fairly frequent expression of the opinion that cancers of the colon are relatively slow in their rate of growth, and that they metastasize late. If these opinions represent the truth of the matter, it must follow that the ratio of cure following resection is materially higher for the colon than elsewhere in the gastro-intestinal tract.

The cases of cancer of the colon, exclusive of the rectum, which have been admitted to the Johns Hopkins Hospital from 1889 to 1919, together with such as are represented by materials sent to Doctor Bloodgood's laboratory during this period though operated upon elsewhere, have been studied in an effort to

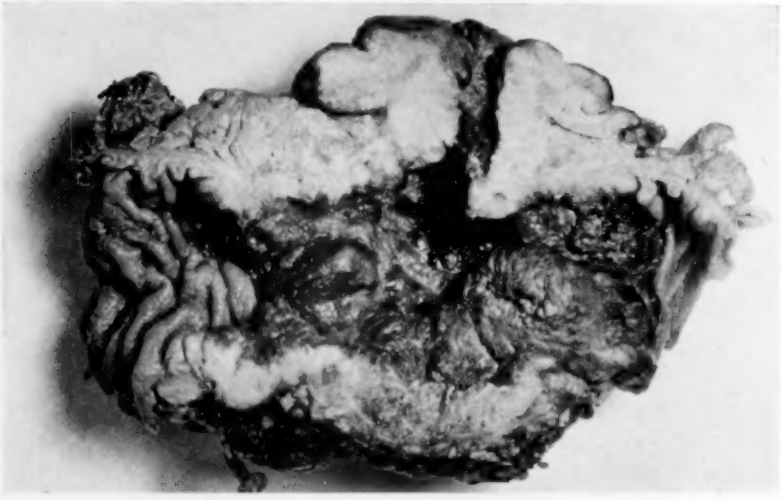

FIG. 1.—P. N. 32666. Adenocarcinoma of the transverse colon, gross specimen. The bowel has been divided longitudinally. Note the large fistula from the colon into the stomach. The excised portion of the wall of the stomach presents the shape of a mushroom on the superior edge of the bowel.

ascertain, among other things, whether these commonly held opinions have an actual basis in fact. The circumstances under which any such group of cases has been assembled are of importance when one attempts to interpret the facts resulting from such a study. This series represents the work of a good many operators, perhaps fifteen in all, and a fairly large percentage of the operations were made by men relatively young in surgery. Practically all of the operators were working under the same conditions, and their surgical efforts represent the result of identical training, but in respect to experience, surgical judgment, and technical ability this series is not entirely comparable to the work of one man. Treatment was uniformly based upon the conviction that if excision was to be made at all, the more radical it could be made within the limits of safety the better; in other words, when feasible there was made a deliberate effort not merely to relieve the patient of an ulcerating mass or of

obstruction, but to effect a definitive cure. The primary growth was excised, and insofar as the conditions governing the individual case permitted, attempt was made to remove also the glands draining the site of the growth. During this period of thirty years the scope of the operation of resection has been gradually extended until, at present, there would seem to be little hope of material improvement in this regard. If then this series of cases may be accepted, within limits, as indicating the effectiveness of our present-day treatment, a study of the results would appear to be of value. The group is made up of 129 cases of cancer of the colon exclusive of the rectum, and covers a period of thirty years beginning in 1889.

Consideration of Clinical Features.—Of the cases studied 77 are male and 42 female, information as to sex being lacking in 10. The ages are shown in the following table:

17 years	1	
20 to 29 years	12	
30 to 39 years	17	
40 to 49 years	28	46.5% of all cases
50 to 59 years	32	
60 to 69 years	21	
70 to 79 years	6	
80 to 84 years	2	
Not stated	10	
Total cases	129	

Fifteen per cent. of the patients were less than 35 years of age.

There are three quite distinct groups to be recognized at the time these patients seek advice; namely, those in acute intestinal obstruction or who have survived such an attack in the past, those who have had definite chronic partial obstruction which has never become acute, and finally those whose history offers no evidence of obstruction. These three groups apparently have a definite mutual ratio, the acute obstruction group representing 19 per cent., the chronic obstruction group 41 per cent., and the non-obstructive group 39 per cent. In other words, of 10 cases seeking advice 4 will give a definite history of chronic obstruction, 4 will present no evident features of obstruction, and 2 either will be in acute obstruction or will give the history of such an attack from which they have recovered. The fact that identical figures were found some years ago by Doctor Bloodgood in an unpublished study suggests the constancy of this group relationship.

The sex ratio within these clinical groups is of little importance; there is a preponderance of men in the chronic obstruction group and of females in the

non-obstructive group. The average age in these two groups is about 50 years, whereas in the acute obstruction group the patients are a little younger (46 years); the average age of the females in the acute obstruction group is 41 years, and that of the males is 51 years. The site of the tumor may be tabulated as follows:

Site of Growth in the Three Clinical Groups

Site of growth	No. cases	Acute obstruction	Chronic obstruction	Non-obstructive.
Cæcum	50, 38%	2	24	24
Ascending colon	5, 4%	1	1	3
Hepatic flexure	12, 9%	2	6	4
Transverse colon	7, 5%	4	2	1
Splenic flexure	8, 6%	2	3	3
Descending colon	6, 5%	2	1	3
Sigmoid	40, 31%	12	16	12
Hepatic flexure combined with second growth in ascending colon	1			

Among the chronic obstruction cases the outstanding feature is the history of recurrent attacks of colicky pain, nausea and vomiting, without apparent cause or perhaps ascribed to some indiscretion in diet and usually relieved without great difficulty by catharsis. In a few cases (6 of 53) these attacks are unmistakable, for the patients describe the onset of "cramps" leading up to a rather severe colic which culminates in a gurgle with the immediate relief of pain and after the lapse of a brief period of comfort a repetition of this cycle. There is frequently a marked tendency to constipation, occasionally diarrhœa, and at times (11 cases) gross blood in the stools is recognized by the patient. Moderate abdominal pain of fairly accurate localization is not uncommon and there is a complaint of gastric distress or of an indefinite discomfort. Among our cases about every fifth patient in this group has discovered an abdominal mass.

Forty per cent. of the cases do not give a history of obstruction, but with them abdominal pain of an indefinite character is usually present. The pain is rarely severe and is variously described as "dragging," "a sense of weight," or "discomfort," the patient at times placing it rather consistently, as, for instance, in the epigastrium or the right lower quadrant. There is a tendency to refer symptoms to the stomach, and frequent mention is made of distress or soreness in the upper abdomen, belching, loss of appetite, and kindred complaints. There has been some confusion with chronic appendicitis. A tendency to diarrhœa is perhaps more frequent than constipation and is occasionally marked; at times blood in the stools is present. About every third patient in this group has an abdominal mass.

The acute obstruction group is made up of 25 cases, 5 among them giving no history of trouble preceding the advent of an "unheralded" complete obstruction. The history of each of the remaining 20 falls naturally into one or the other groups just outlined, differing only in that the patient

had survived one or more stormy attacks of acute obstruction which were apparently complete for the time being but did not prove fatal. The 5 cases of "unheralded" obstruction represent 4 per cent. of the entire series, and if to this 4 per cent. who have no previous history of obstructive symptoms we add the 40 per cent. who at no time offer evidences of obstruction, it is seen that almost one-half (44 per cent.) of all cases of cancer of the colon lack this tell-tale symptom, which is commonly regarded as characteristic of the disease. The diagnostic importance of this fact is obvious; our figures do not support the opinion that cancer of the colon very

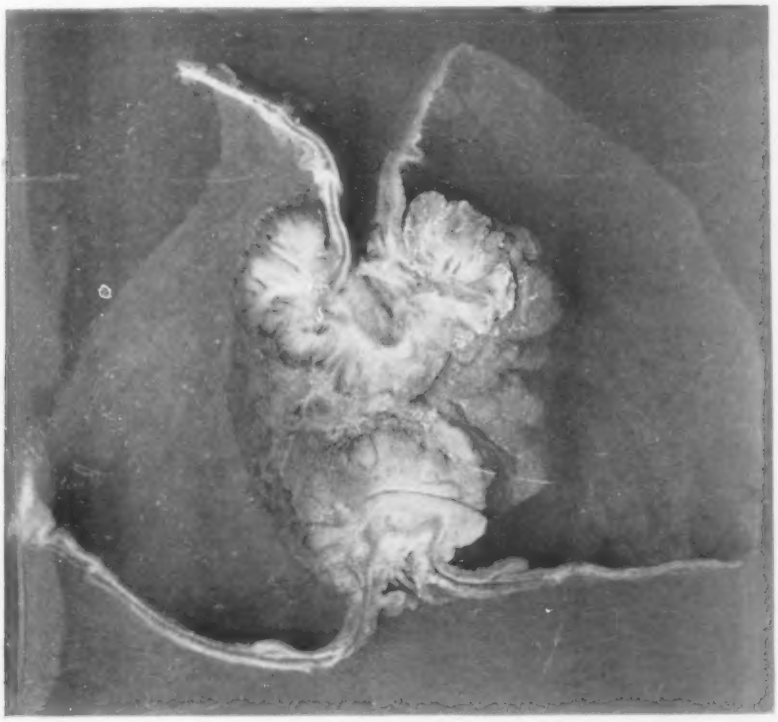

FIG. 2.—P. N. 10253. Cancer of the colon. Gross specimen.

generally produces obstruction. However, as has just been pointed out, close study of the histories shows that, with few exceptions, the cases show certain symptoms which can hardly escape the patients' recognition, and that even though evident partial obstruction is not present in more than one-half, yet those lacking this symptom present other evidences of disease which are quite as obvious and whose explanation would be just as vigorously sought if their possible significance were understood by those so afflicted.

The duration of symptoms in all cases here represented averaged 16 months. In general the patients are seeking treatment somewhat earlier today than they did 25 years ago, but not to a striking degree, for when

this is studied by periods of five years it is found that the present-day duration of symptoms is 13 months as against 19 months 25 years ago. Moreover, the evidence of this series shows that the shortening of this period affects but one of the three clinical groups; the acute obstructions and the chronic obstructions appear to be coming to treatment a little later than they did years ago, and the only group seeking relief earlier than formerly is the non-obstructive group, in which 22 months represents the average duration of symptoms 30 years ago and 8 months represents the average

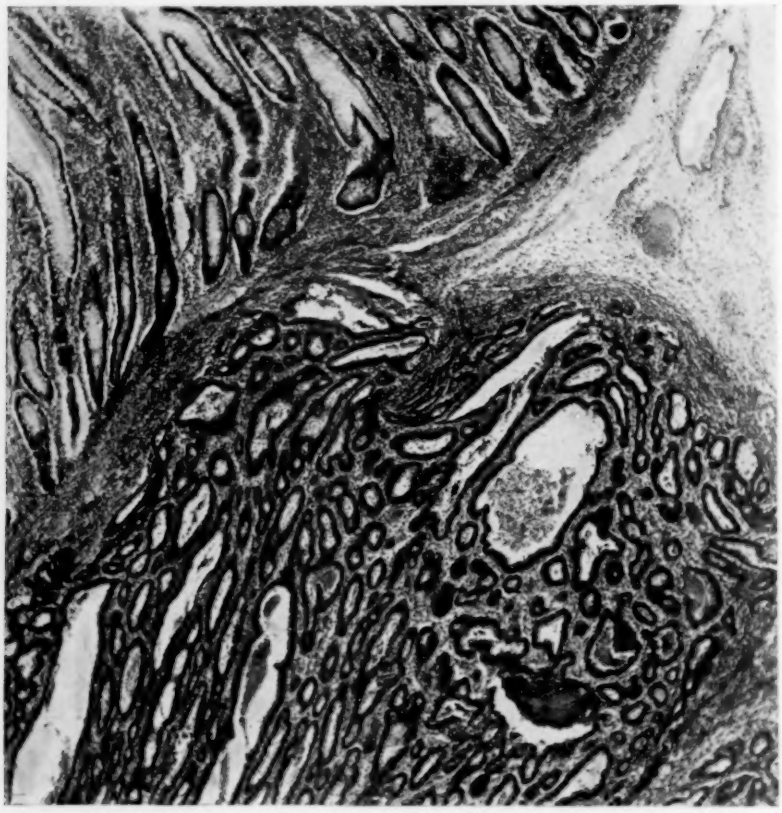

FIG. 3.—P. N. 28918. Adenocarcinoma of the colon. A large majority of the cancers of colon are of this type. The picture shows direct extension of the growth along the bowel wall, undermining the normal mucosa; this is seen very frequently.

duration to-day. Inquiry developed the fact that this improvement was not due to the advent of the X-ray as a help in diagnosis; before this method of examination was in current use there had been a drop from 22 to 13 months in duration of symptoms.

Judging from this series, it appears that for many months these patients consistently present symptoms which can hardly escape recognition, and yet, in the face of this fact, they fail to appreciate the significance of these

symptoms or to investigate the cause of the trouble; this state of affairs apparently presents an excellent opportunity for an effort to bring the public to understand that persistently recurring partial obstruction, or unexplained abdominal pain accompanied by blood in the stools, may be a warning of serious trouble. Reduction of the duration of symptoms offers more than further technical elaboration of the operative treatment.

Pathological Features.—The tumors are almost uniformly adenocarci-

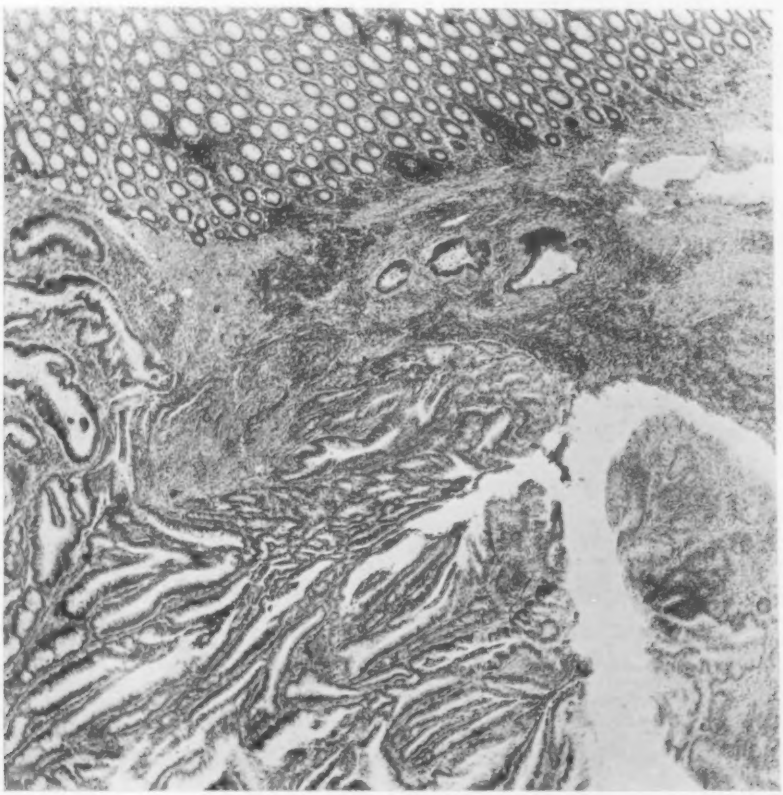

FIG. 4.—P. N. 31610. Adenocarcinoma of the colon showing direct extension of the growth in the bowel wall, undermining the normal mucosa. The advancing edge of the cancer is well shown in the lower right-hand portion of the picture.

noma and show a definite tendency to reproduce roughly the glands in the wall of the bowel. Most of the growths have a decided excess of epithelium with a correspondingly limited amount of fibrous tissue, so that there is usually produced a fairly large mass. The extreme scirrhous type resulting from fibrous overgrowth and producing a marked degree of obstruction is infrequent in this series. There is found at times a certain amount of colloid degeneration. In the earlier cases perforation of the bowel with a secondary abscess is not infrequent, there being 16 such cases, the latest of which was recognized in 1913. Excepting one case which apparently shows a carci-

noma developing from a benign adenoma, there was found very little evidence of cancer developing in a preëxisting lesion. The presence of diverticula or of benign ulcers was not observed; if such preëxisting lesions had served as the point of origin of a cancer it is probable that they would have been so completely obscured by the long-standing malignant disease as to escape recognition. These tumors are of course almost invariably single, but there are 4 cases in the series which seem to represent simultaneous development of cancers at two different points. Cancers of the cæcum and sigmoid account for 70 per cent. of the tumors of this series, these two sites being about of equal frequency; the remaining 30 per cent. are scattered indifferently along the other parts of the colon. One-half of the acute obstructions were due to cancers of the sigmoid; almost one-half of the tumors in the chronic obstruction and non-obstructive groups were of the cæcum.

Treatment.—Among 129 cases there were but 70 treated by resection; that is to say, in barely over 50 per cent. was it considered advisable to attempt resection. The earlier cases date back 20 years or more to a period when tardy diagnosis and doubtful technic reduced the number of operable tumors. In 70 resections there were 24 post-operative deaths, an operative mortality of 35 per cent. This is undoubtedly high; in contrast to it stands the fact that since 1919, 14 resections have been made with but one death, a resection of the transverse colon and stomach for cancerous gastrocolic fistula. The cause of death in these 24 post-operative fatalities was as follows: peritonitis, 8; obstruction, 3; embolism, 3; shock, 2; volvulus, duodenal fistula, broncho-pneumonia, lung abscess, uræmia, non-functioning anastomosis, "fulminant recurrence," each 1 case, with the cause not stated in an additional case. Of the 8 peritonitis deaths 2 followed the comparatively simple procedure of mobilization of the growth, carried out as the first stage of a proposed Mikulicz operation; these occurred early in the series and probably represent tumors that would be considered inoperable to-day. Six peritonitis deaths were due to failure of the intestinal stitch, four times in lateral and twice in end-to-end anastomoses, all but one of which concerned the sigmoid. When one examines the operative method followed in the 24 fatal cases, it is found similarly that there is a higher mortality ratio among the lateral anastomoses than the end-to-end sutures; namely, 34 per cent. as against 17 per cent., and even though these deaths are not all due to peritonitis resulting from insecure suture, nevertheless the contrast in the figures is striking and possibly significant. Of late years there has been rather a tendency to prefer lateral anastomosis to end-to-end anastomosis, on the assumption that the threat of necrosis of the bowel, due to unavoidable operative interference with its circulation, is more adequately met, but the figures of this table, while by no means conclusive, do not seem entirely to support this impression. It is probably nearer the truth to admit that neither type of anastomosis is dependable if there is any question as to the adequacy of the circulation, and that it is safer to meet this operative problem either by fixing both stumps in an extraperi-

toneal position or, where possible, by resecting enough gut to ensure viable tissues.

There is a marked contrast in the risk involved in resection and suture in the various regions; thus operations on the transverse colon had a mortality of 57 per cent., on the left colon of 41 per cent. and on the right colon of 25 per cent., which conforms rather accurately to the general feeling among surgeons today as to the relative danger. There was a high mortality in 5

FIG. 5.—P. N. 28443. Colloid cancer of the colon. The growth shows a definite tendency towards a glandular arrangement, with marked production of colloid. In frequency of occurrence this type of growth ranks second, adenocarcinoma without colloid production being first.

resections of the descending colon, among which 3, or 60 per cent., died, and in 4 resections of the splenic flexure, of which one-half died. This bears out the feeling expressed by Dr. John A. Hartwell in a paper read before this association in 1917. The lowest mortality, namely, 24 per cent., is found in resection and lateral anastomosis on the right side, and, excluding the few Mikulicz operations, the highest mortality rate is in lateral anastomoses of the transverse colon; namely, 75 per cent. The transverse colon seems to be a particularly dangerous area, and our figures may perhaps serve as an argument

for a wider resection than many surgeons have been accustomed to make. There is definitely presented the question whether, in cancer of the right or of the transverse colon, it is not wiser to remove the growth and all of the large bowel proximal to it and to restore the continuity of the tract by a lateral anastomosis of the ileum with the remaining colon. Our figures suggest that if the patient's condition permits, the intestinal suture will be more dependable if this plan is followed than if an attempt is made to restore the

FIG. 6.—P. N. 29017. Carcinoma of the colon. There is a marked tendency towards the production of fibrous tissue, the resulting picture rather suggesting scirrhous cancer. The tendency of the epithelium to maintain a glandular arrangement is still evident. This is the least common type.

continuity by anastomosis of the proximal and distal loops of the colon, but, as will be pointed out a little later, while extending the operation to this limit seems to offer more safety from the standpoint of suture, it fails to offer any additional security with reference to recurrence of the growth. The indication for this extension of the operation, therefore, is not drawn from the figures referring to ultimate cure but solely from the statistics referring to the immediate post-operative result.

Among the clinical groups the lowest mortality from resection was in the

acute obstruction group; apparently this was due to the fact that most of these cases were treated by a preliminary ileostomy or colostomy. Six were submitted to immediate resection, with one post-operative death. Nineteen were submitted to preliminary colostomy; these were obviously the sickest patients of the group, and among the 19 there were 6 deaths following colostomy, but among the 13 surviving colostomy, 12 were resected without immediate post-operative mortality. Thus the resections in the three clinical groups compare as follows with reference to mortality: acute obstruction, 20 per cent.; chronic obstruction, 39 per cent.; non-obstructive, 38.5 per cent.

To sum up: In 70 resections scattered over a period of 30 years there has been a mortality of 35 per cent., and this mortality has been higher with resection of the left colon than the right colon. The most dangerous region has proved to be the transverse colon and its distal extension. No doubt this high regional mortality is due not alone to circulatory difficulties but also to the richer and more virulent bacterial flora of the lower operative field. End-to-end suture in this series has been attended by a lower mortality ratio than lateral anastomosis, but rather than indicating great advantage for either method of restoring the continuity of the gut, our figures suggest that, with tumors of the right or transverse colon, if the patient's condition permits it is perhaps better to excise the cancer and all of the colon proximal to it, restoring the continuity by anastomosing the ileum to the remaining portion of the colon rather than to anastomose colon to colon after resection of no more than the growth-bearing sector of the bowl.

Analysis of Five-year Cures.—Practically all of these patients have been traced and their ultimate fate is known. There are only 13 five-year cures. This represents 10 per cent. of the admitted cases, 19 per cent. of the resected cases, and 28 per cent. of those surviving resection. In other words, the five-year cures represent 1 in 10 of all admitted cases, 2 in 10 of every resected case, and 3 in 10 of every resection surviving operation. In the face of the figures, it requires a considerable degree of optimism to regard cancer of the colon as a " favorable " type of the disease.

Of the 13 five-year cures, 8 came from the clinical group showing chronic obstruction, 3 from the acute obstruction group, and but 2 from the non-obstructive group. Of the 3 cases from the acute obstruction group, none had shown any obstruction symptoms in their past histories; one of these 3 was of the " unheralded " complete obstruction type and had had no previous symptoms, the other 2 had each had abdominal symptoms for two years, but not obstructive in character. Thus in 13 five-year cures only 8, or 60 per cent., had attacks of partial intestinal occlusion which finally forced them to seek advice. It was shown above that about 56 per cent. of all cases of cancer of the colon have a history of partial obstruction. These two figures, *viz.*, 60 per cent. and 56 per cent., are practically identical; their close correspondence forces one to the conclusion that the symptom of chronic obstruction has proved of little aid

toward early diagnosis. If the partially obstructing cancer had forced recognition of its presence earlier and so offered better chance of cure than the others, we would find a distinctly higher cure ratio among those of the first mentioned type; the fact is that our figures show almost the same proportion of chronic obstruction histories in all cases as in the five-year cures. The discrepancy between this fact and the rather generally held opinion is evident.

The relation between the length of time the disease has been present and the chance of cure is clearly shown; the 8 five-year cures in the chronic obstruction cases had an average duration of symptoms of 6 months as against an average duration of 11 months for all the cases of this group. Among the 51 cases of the non-obstructive group the average duration of symptoms was 19 months, but the 2 cures had shown symptoms for only 6½ months preceding resection. In the acute obstruction group there is no difference in this respect between the 3 cured cases and the 22 uncured cases, and it is an interesting fact that only one of the 3 came to operation because of acute unheralded obstruction.

The site of the growth in the cured cases is of interest. The first five-year cure of which we have record was operated upon in 1894 for carcinoma of the cæcum, and the second was also a right-sided growth, a cancer of the hepatic flexure resected in 1899. Of the 13 cases 6, or nearly one-half of the five-year cures, were carcinoma of the cæcum, 2 were carcinoma of the hepatic flexure, 1 was a cancer of the transverse colon, and only 4 were cancers of the sigmoid. It has been held by many observers that from the standpoint of cure the sigmoid is a relatively favorable site because of the frequency of early obstruction with this situation, and it is true that one-half of the acute obstructions occur at the sigmoid, but it has just been shown that the potential help of obstruction as a symptom has not as yet been developed; only 4 of 13 five-year cures had cancer of the sigmoid in spite of the decided tendency toward obstruction at this site.

The type and extent of operation is of very considerable interest. Eleven of the 13 cases were treated by immediate resection and anastomosis; 2 acute sigmoid obstructions in females were treated by preliminary colostomy and secondary resection. In the amount of gut removed there is great variation among the 13 cases, and it appears that, so far as recurrence is concerned, this point is of relatively slight importance provided all of the primary growth is excised. In 8 instances the resection was extensive in the sense that the tumor was removed together with a generous amount of obviously healthy bowel wall; the tissue of only one of these showed metastases to the glands. There were 5 limited resections, *viz.*, 10 cm., 9 cm., 4 cm., 20 cm. (which, however, cleared the edge of the growth on one side by only 3 cm.), and one of less than 4 cm.; none of the 5 showed involved glands. In spite of this variation in extent and more particularly of the decidedly limited amounts removed in at least 2 cases, *viz.*, 4 cm. and less, all of the operations accomplished the same result in that

the patients were clinically free from disease for at least five years and in most instances longer.

All of the material was studied carefully and excepting that from one of the extensive resections, no metastatic glands were found; thus 12 of the 13 cured cases were operated upon at a time in the development of the tumor when complete local removal, no matter how limited a resection this implied, accomplished as much as any operation, regardless of its extent. The one case

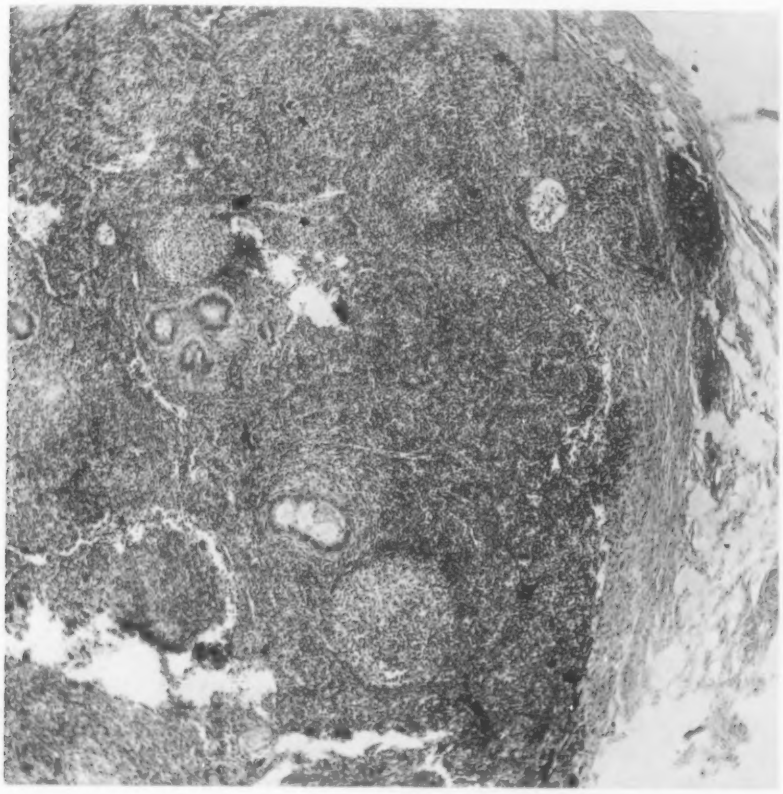

FIG. 7.—P. N. 31610. Adenocarcinoma of the colon, early metastasis to a lymphatic gland. Note the persistent tendency towards a glandular arrangement of the epithelium.

showing metastatic glands remained well over six years and replied to the follow-up letters willingly and promptly; at the end of six and a half years her replies stopped abruptly, and it has been impossible to obtain any further information. Although we are ignorant of her fate, it is altogether probable that recurrence of the cancer explains her disappearance, this assumption being strengthened by reason of the low rate of cure in this series as well as by the knowledge that a considerable proportion of the recurrences appear after the end of the fifth post-operative year. If our assumption is correct, there remains no evidence in this series that cancer of the colon is curable by opera-

tion after it has invaded the lymphatic glands. It is unfortunately true that but few of these cases will come to operation before the glands are involved; if it is equally true, as our evidence apparently indicates, that cancer of the colon in this stage of development is rarely if ever curable by operation, there is every reason for us to strive by intelligently directed educational efforts to bring these cases to operation earlier while they are still curable rather than to extend the limits of operation. Judging from this series it seems quite probable that just as much can be accomplished by a limited operation which clears the primary growth as by any operation; there would seem to be no indication for exceedingly wide resections other than circulatory conditions of the colon which appear at times to make ileocolostomy safer than colocolostomy.

There is little to be said of the type of tumor found in the cured cases. Twelve were of the usual adenocarcinomatous character, growths in which the epithelial elements clearly predominate, forming more or less bulky masses which present, in the lumen of the gut, an irregular ulcerating surface outlined

Date of Recurrence

	Number cases	Per cent. of total number cases with recurrence of known date.	
1st p.o. year	8	50	
2d p.o. year	2	12.5	75%
3d p.o. year	1	6.25	
4th p.o. year	1	6.25	
6th p.o. year	1	6.25	25 per cent. of all recurrences appear after the 5th year.
7th p.o. year	1	6.25	
8th p.o. year	1	6.25	
16th p.o. year	1	6.25	

by a thickened rather elevated edge. The ulcerating surface in this type of growth is apt to bleed easily. There is only one scirrhous tumor among the 13; this case is a nine-year cure and the details are sufficiently interesting to merit recording. Following the drainage of a subacute, thick-walled gall-bladder, the patient had a rather stormy convalescence, and on the twentieth day was explored because of a diagnosis of pancreatitis. During the approach to the pancreas the transverse colon was drawn out of the abdomen, and there was found in its distal half a small scirrhous stenosing cancer, which was removed with a rather narrow margin on each side of the growth, no attempt being made to remove the glands. The patient made an uneventful recovery, and nine years after operation was well.

Recurrence.—Among the 26 instances of proved or probable recurrence following resection there are 16 in which the date at which the recurrence was first definitely recognized is known. The information concerning these 16 is recorded in the appended table:

Fifty per cent. appear within the first year and 12.5 per cent. during the

second post-operative year; after that time, however, there seems to be a definite tendency toward tardiness amounting in a few to marked delay. It is not reassuring to realize that the first five years elapsing after successful resection account for only 75 per cent. of the recurrences which will appear; 25 per cent. are first recognized after apparent freedom from disease for more than five years. The length of time which must elapse after operation before a case may be regarded as actually and finally cured is altogether obscure;

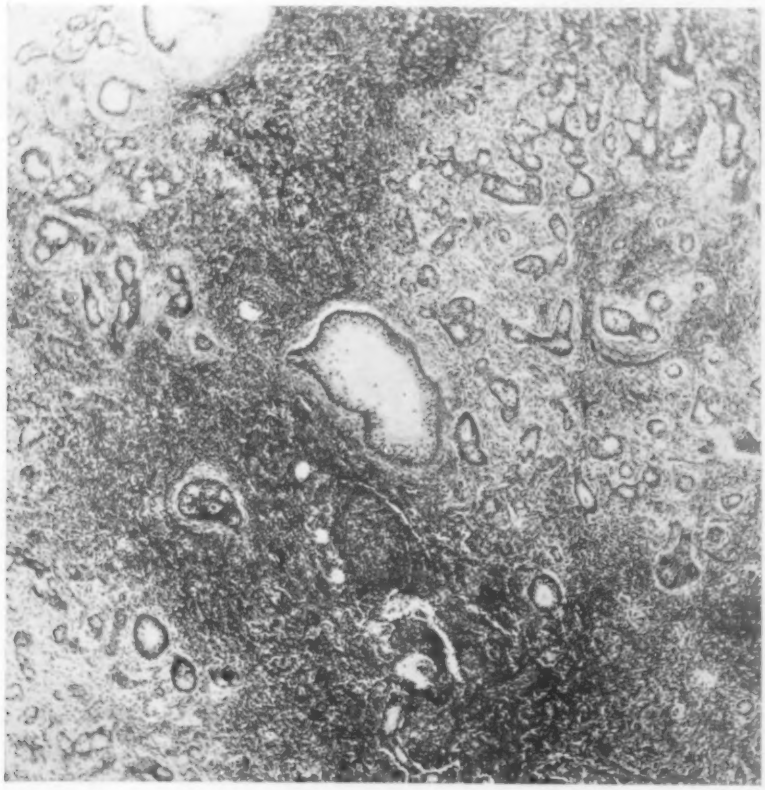

FIG. 8.—P. N. 31835. Colloid cancer of the colon, metastasis to a lymphatic gland. The structure of the lymphatic gland is still seen in a transverse strip across the middle of the picture; elsewhere the carcinomatous growth has largely replaced the lymphatic tissue.

it is certain, however, that five years' freedom is not sufficient. In addition to the 16 cases whose date of recurrence is known there remain 10 cases who left the hospital alive but were lost; it is probably not far from the truth to regard these 10 as recurrence deaths, and our figures then show 26 recurrences, which represents 56 per cent. of the resections surviving operation.

There are two cases not taken account of in the figures presented above which illustrate very definitely the insecurity of regarding five years' post-operative freedom from disease as equivalent to a cure. The first of these

cases was a woman aged thirty-eight who came to operation because of dyspepsia and mild constipation present for three and a half months. At operation there was found a cancer of the cæcum which was resected. Sixteen years later this patient died of cancer of the liver; although it is not absolutely certain that this was a recurrence, the probability of such being the case is quite apparent. The second instance is a woman aged fifty-nine, admitted in acute obstruction, which was treated by a preliminary colostomy, followed a little later by resection of a cancer of the transverse colon. Five and a half years later, laparotomy disclosed a mass of carcinomatous glands in the right lower quadrant, which were regarded at the time of operation as metastases from the growth in the transverse colon. Here are two cases showing carcinomatous growth well after the expiration of the five-year limit, and while the metastatic character of the glands in the second case is not wholly clear, it is all but certain that in each instance we are dealing with but the one disease and not with the development of a second independent growth. It would be of extreme interest to know the actual outcome in all of our cancer operations today. There is reason to believe that many cases now classed as cured on the basis of five years' freedom from disease ultimately succumb to recurrence of the original growth; our statistics as to cure would probably not be improved by following this matter in detail.

SUMMARY

The basis of this study is 129 cases of cancer of the colon exclusive of the rectum which applied for treatment during the years 1889 to 1919. At the time of admission only a little over one-half of them presented a history of partial intestinal obstruction. Forty per cent. of the cases had shown no symptoms of obstruction, 40 per cent. had a definite history of chronic obstruction, and 20 per cent. were admitted in acute obstruction or had previously survived such an attack. The history of partial obstruction, when given, extended over the better part of a year before admission for treatment; those lacking this feature presented other symptoms, which had been recognized by the patient for a period of comparable length. Resection produced a five-year cure in 10 per cent. of all the cases admitted and in 28 per cent. of those surviving resection. Examination of the tissue removed disclosed but one case with metastasis to the lymphatic glands, and this case was lost sight of six and a half years after operation; inasmuch as 25 per cent. of the recurrences appear after the end of the fifth year it is reasonable to assume that this patient died of recurrence, in which event there is no evidence in this series to show that cancer of the colon is curable by operation after metastasis to lymphatic glands has occurred. There is reason to believe that if a case is curable by surgical means this result will be achieved just as surely by local excision of the growth-bearing portion of the gut as by an operation of much greater extent; from the standpoint of cure, therefore, limited resection which

definitely clears the growth appears to meet the situation, but the arrangement of the circulation of the colon is such that one may be forced to make a much more extensive resection in order to be assured of the viability of the remaining tissues. Only a small proportion of these cases are now coming to operation at a time when surgery can cure; practically all of them, however, have had definite trouble for months, frequently more than a year. Great benefit would no doubt result from a deliberate educational effort directed toward reducing the period of time which at present intervenes between the first appearance of symptoms and the final decision for operation. Apparently a decided improvement in our cure ratio can be brought about in no other way.

EMBRYOMA OF THE KIDNEY*

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and
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The kidney during the periods of infancy and early childhood is a frequent seat of malignant disease. One of the responsible new growths has been given the general term embryoma.

Ewing defines embryoma as a tumor composed of tissue from the three germinal layers in more or less orderly imitation of a fœtal tissue. This new growth has been classified in the past as sarcoma, hypernephroma and carcinoma; and it was not until after Birch-Hirschfeld pointed out the existence of a definite embryonal mixed tumor that points of differentiation were reached. The origin of these new growths is purely theoretical, varying from that of aberrant sex cell (Ribbert), to a later teratogenic terminative period, from the renal blastoma (Busse and Muus) as quoted by Ewing.

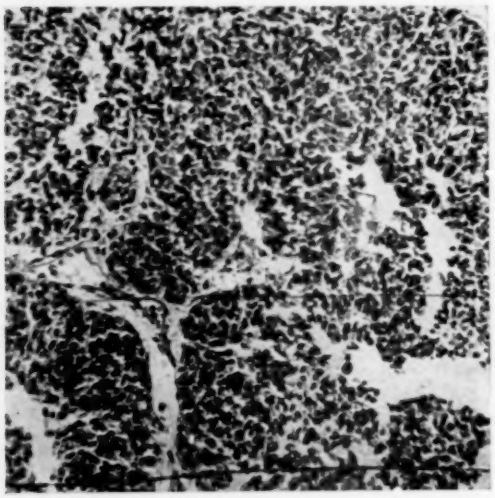

Fig. 1.—Case I. Showing masses of rapidly growing tumor cells, surrounded by a thin, loose layer of connective tissue. In places the cells show attempts at the formation of atypical renal tubules.

Grossly the tumors lie within a distended renal capsule with their position suggesting an origin from any part of the kidney substance; and furthermore may present themselves as entirely extra-renal. They may attain very large size, Ewing cites reported cases in which the tumors were from 35 to 40 cm. in diameter, weighing as much as 3580 grams.

Macroscopically they may be solid or cystic, in the latter case closely resembling congenital cystic kidney. In some of the later cases the entire kidney substance has given place to new growth, whereas in the earlier stages normal kidney tissue remains in more or less isolated spots, as in one of our cases, occupying the lower pole.

When cysts appear they may be numerous, glistening, varying in size, filled with clear or straw-colored fluid, and encroaching upon the remaining kidney substance. Where but a few cysts are present they may be in close proximity to each other or isolated.

Microscopically, as described by Mallory, embryoma appears most often as

* Read before the American Surgical Association, May 31, 1923.

a cellular rapidly growing tumor, with little stroma and fairly characteristic cells, which show no differentiation.

On the other hand, when the tumor is growing more slowly the cells are able to differentiate, and various recognizable types of cells and tissues may be formed. Thus muscle, both smooth and striated, fat, cartilage and bone may be seen. A frequent attempt at forming abortive tubules and glomeruli is noted. The individual, undifferentiated cell may be spindle, cuboidal, or giant in type, and usually presents the rapid proliferation characteristic of embryonic tissue.

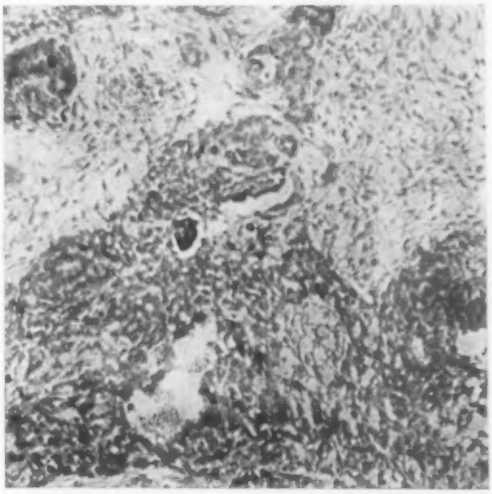

FIG. 2.—Case II. Showing lobular masses of mesenchymal tissue. The cells show rapid proliferation and with higher power, many of the cells could be seen undergoing a mitosis. The connective tissue stroma is more pronounced with areas consisting of myxomatous cells. Here too there is a tendency toward the formation of atypical renal tubules.

When we consider the diagnosis and treatment of these new growths, we have the same problem to face that we note in dealing with malignancy in general. More difficult, if possible, for the cases necessarily come into the surgeon's hands late, and the course of the disease is very rapid.

The symptomatology is a handicap, for it is decidedly vague. Frequently the first evidence of trouble is the appearance of a tumor mass. Warnings when they do appear, as in the form of malaise, slight temperature, abdominal distention or discomfort, diarrhœa or constipation, are so insignificant, that they are not looked upon seriously until too late. Loss of weight, anemia, and hæmaturia usually mark only the advanced cases.

The operative treatment presents two problems; first, the fact that malignant disease has to be dealt with, which in the majority of cases has gained a firm footing; and secondly, the work must be done on a subject young in years, and many times in poor condition. As Mixter points out, the majority of cases are under five years of age; and in his series nephrectomy gave an operative mortality of 35 per cent., and simple exploration 44 per cent. The same author quotes the figures of Loughnane, who noted 7.7 per cent. with nephrectomy, 28 per cent. with simple exploration, and gives the following results obtained:

Four cases well at the end of four years, two at the end of two and one-half years, three lost track of, two dead from recurrence at the end of six months, and one dead of phthisis three months after operation. Mixter further mentions that Loughnane collected 35 nephrectomies from the London hospitals. These showed over 85 per cent. recurrences, 70 per cent. occurring within one year.

Although mention is made in the literature of nephrectomy with removal of the retroperitoneal gland tissue as a possible means of securing an ultimate cure, it is our opinion that such a procedure can only result in even a higher operative mortality than now exists.

In our experience, even those cases which present good risks suffer from severe shock, greater even, when we have done nothing more than a rapid and nearly bloodless nephrectomy. Very young children withstand major procedures none too well. Furthermore, we believe that the advanced cases, that is, those with anemia or any degree of cachexia are better left alone. After operation intensive X-ray treatment may be tried, although we have yet to see any benefits derived therefrom.

FIG. 3.—Case III. Showing the gross appearance of the kidney in Case III.

Metastasis is not common in the case of embryoma, the liver and lungs being frequently invaded when it does occur. Local recurrence is, however, the rule, and it makes its appearance usually within six months to two years. After four years, as noted by Loughnane, recurrence is rare.

The three cases we desire to place on record present no unusual features. Two presented cystic changes, and one was quite advanced. All three were composed of the undifferentiated type of cells. Two were operated upon by the authors, and one by Dr. B. H. Alton, to whom we are indebted for the privilege of reporting his case. We also desire to thank Dr. Roger Kinnicutt, Pathologist to Memorial Hospital, for the ultimate diagnosis.

FIG. 4.—Case III. The same kidney laid open. The numerous cysts appear with the normal kidney substance and ureter showing at the upper pole.

CASE I.—Male, age four years, American. Normal birth and infancy. Some months before admission child's parents noted some enlargement of abdomen, but gave it no particular notice. Four days before admission child had abdominal discomfort, slight temperature and was drowsy. Following day temperature was

102° F. Admitted to hospital with diagnosis of possible appendix abscess. Urine normal, white count 11,200. Physical examination negative except for a mass, palpable in right kidney region. Laparotomy with right nephrectomy through abdominal route. Left kidney normal. Uneventful recovery.

Gross Pathological Report.—Kidney presents several cysts occupying both poles. Also at each pole are tumor masses, each measuring about 8 cm. in diameter. These are encapsulated and walled off from the rest of the kidney substance. Tumor tissue is soft, friable and grayish in color. Scattered through it are hemorrhagic and cystic areas.

Histological Examination.—The tumor consists of lobular masses of mesenchymal tissue, the lobules being surrounded by a thin loose layer of connective tissue. In places these cells show attempt at the formation of atypical renal tubules.

Diagnosis.—Malignant tumor of mesenchymal origin. Embryoma.

Local recurrences six months after operation. Massive X-ray treatment for several weeks, death nine months after operation.

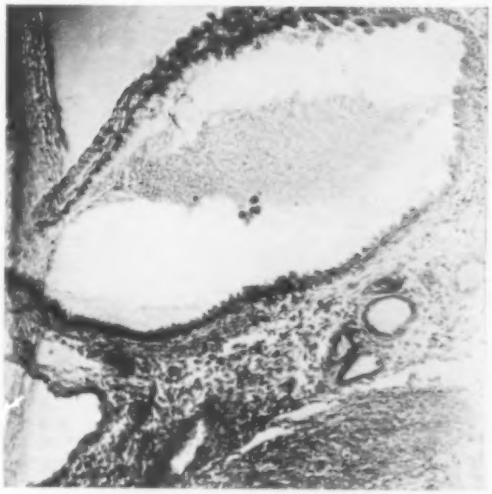

FIG. 5.—Case III. A microphotograph of one of the cysts, to show the lining cells. The papillæ are covered with cuboidal or high columnar epithelial cells. These proliferating cells are gradually filling the cystic areas. About these cysts are layers of connective tissue, mucin-like tissue and scattered atypical tubules.

CASE II.—Female, age two years. Polish. Normal birth, breast fed, no illnesses. Child's parents had noted enlargement of abdomen, formation of a mass and hæmaturia for one month before seeking medical advice. Admitted from out-patient department with diagnosis of sarcoma of right kidney. Urine loaded with blood and pus. White count 27,300. Hæmoglobin, 50 per cent. Red count, 4,072,000. Temperature, 100° F. P. M. N.—57 per cent. S. L.—17 per cent. L. L.—5 per cent. Trans.—4 per cent. Eos.—17 per cent.—100 per cent.

Physical examination showed a very pale, weak, but fairly well nourished child, apparently normal except for a mass occupying right kidney region and not freely movable.

Abdominal exploration under ether in the hope that an inflammatory condition might be found and relieved. Advanced new growth existed however, replacing right kidney substance. The tumor was soft, grayish in color, and had adhered to the liver, duodenum and loops of small bowel.

The peritoneal cavity was filled with free bloody fluid. Left kidney normal.

Right nephrectomy after freeing tumor and thereby creating free bleeding. Profound shock noted before operation was completed. Child made an ultimate uneventful recovery.

Histological Examination.—The tumor consists of lobular masses of mesenchymal tissue, the lobules being surrounded by a thin, loose layer of connective tissue. In places these cells show attempt at the formation of atypical renal tubules, and there are also areas consisting of myxomatous cells. Many cells seen in mitosis.

Diagnosis.—Embryoma. Local recurrence large enough to be palpable, four months after operation.

Death from recurrence March 3, 1923, six months after operation.

Case III.—Male, age one year. American. Normal birth and infancy, no illnesses. Two months previous to entrance child's mother noted fullness in abdomen on right side below ribs. Child's operation delayed by a cough, but finally admitted to hospital with diagnosis of probable embryoma. Urine normal, white count 16,200. Hæmoglobin 65 per cent.

P. M. N.—28 per cent. S. L.—18 per cent. L. L.—45 per cent. Trans.—9 per cent.

Temperature normal. Abdominal nephrectomy. Severe post-operative reaction. Ultimate uneventful recovery. At time of removal a diagnosis of congenital cystic kidney was made.

Pathological Report.—Dimensions after collapse of some of the large cysts, 10 x 6 x 4 cm. Weight of cystic fluid and specimen 275 grams. Kidney tissue pale, and walls of cysts are gelatinous, gradually becoming dense and fibrous near kidney tissue.

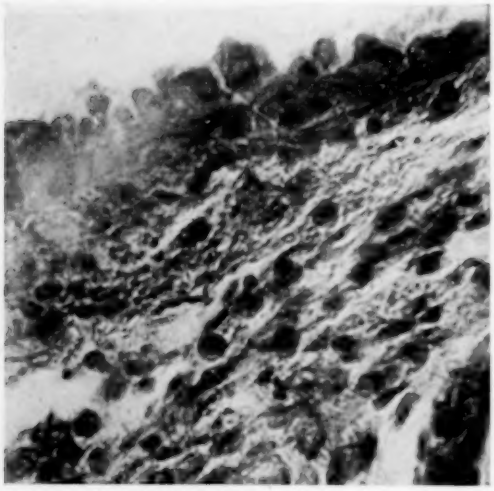

Fig. 6.—Case III. High-power of the lining layers of one of the cysts. These rapidly growing cells vary in shape from flat cuboidal to columnar epithelial cells. The underlying round and connective tissue cells are shown.

Histological Examination.—In the remains of the kidney is a large amount of dense connective tissue, with scattered collections of round cells with deeply stained nuclei. In places the glomeruli and tubules are normal in appearance; but for the most part they are either compressed or replaced by dense connective tissue.

Below this cortical layer is a band of connective tissue containing no kidney structures; below this layer is looser connective tissue, mucin-like tissue and scattered atypical tubules. The walls of the cysts are irregular in outline, the irregularity due to the papillæ covered with cuboidal or high columnar epithelial cells. In the tissue adjoining the cysts are small, irregular cystic areas lined with flat to cuboidal epithelium.

Diagnosis.—Cystic kidney, embryoma. No evidence of recurrence at end of five months.

It is only fair to assume that in view of the usual course of these new growths and the difficulty of arriving at a diagnosis, the mortality will continue to be high. The results of operative interference can only be improved if earlier diagnosis can be made and earlier and more radical excision practiced.

It is not at all certain that this can ever be successfully accomplished. Meanwhile it is probably best to continue doing as radical a nephrectomy as possible, so long as even a very small percentage of cases survive and remain free from recurrence for several years.

We believe, however, in view of the high mortality and high percentage of recurrences that the family should be fully appraised of the gravity of the case and the slight prospect of relief.

CERTAIN FEATURES OF RENAL CALCULUS*

By Ellsworth Eliot, Jr., M.D.
of New York, N. Y.

The wide variation observed in the pathology of renal calculus accounts for the great irregularity of its clinical manifestations. Calculus may be single or multiple, in one or both kidneys, possessed of rough or smooth surface, situated in either the parenchyma of the organ or in the pelvis or in both places simultaneously. If in the parenchyma it enjoys little if any movement; on the other hand, in the pelvis small calculi if not adherent to its walls usually are freely movable, and if too large to pass through the ureter may intermittently occlude the pelvic outlet. Furthermore calculi vary in the rapidity of their formation and their growth may be intermittent as the character of the urine becomes more or less favorable to the precipitation of its mineral constituents. That calculi should form simultaneously in both kidneys is a natural inference, yet such an occurrence is the marked exception, and is perhaps accounted for by the fact that the chemistry of the urine collected by ureteral catheterization from either kidney does not always show the same composition and may vary to such an extent as to actually differ in reaction.

Renal calculi, through their irritation, cause an intermittent non-infectious inflammation of the mucous membrane of the pelvis or, if in the parenchyma, of the connective tissue stroma of the organ as well as a productive inflammation of the perinephritic connective tissue proper. This latter condition leads to the formation of more or less dense adhesions between the kidney and its investing capsule, because of which in the course of the operation for the removal of the stone the delivery of the kidney to the surface of the wound may be greatly impeded. By the contraction of this same tissue the pedicle of the kidney may be shortened, and in one instance observed by the writer this contraction was so marked that the poles of the kidney were approximated. The kidney pelvis in consequence was so concealed from view that the calculus within its cavity could only be removed through an incision in the kidney parenchyma. On the other hand, total absence of any change in the perinephritic tissue is well demonstrated in Case I, in which both subjective and objective symptoms indicated a freely movable kidney. The calculus was detected in the course of routine X-ray examination and easily removed through the usual incision in the posterior wall of the pelvis. The writer in the past has operated on many cases of movable kidney, and in no instance was a calculus found in the exposed pelvis.

The writer refrains from any reference to the pathological changes due to pyogenic infection in a kidney containing calculi. Such a condition usually

* Read before the American Surgical Association, May 31, 1923.

develops, if at all, in the later stages of the lesion and after the calculi, by obstruction, have caused distention of the pelvis and calyces.

While renal calculus with or without calculi in some other part of the urinary tract is usually uncomplicated with lesions in other organs, the writer has observed one instance in which there existed a cholelithiasis, another in which a carcinoma of the stomach had been successfully removed, while Case IV shows a tuberculosis of the affected kidney. In Case III, an intra-ligamentous cyst was first removed.

The gross pathology of renal calculus has thus been briefly outlined, for the purpose of emphasizing the difficulty of correlating the subjective symptoms into well-defined clinical groups. These subjective symptoms therefore, while of relatively little diagnostic value, are at least important in leading to X-ray examination, and for that reason deserve study and consideration. In omitting their exhaustive enumeration it is nevertheless important to call attention to the fact that pain, unquestionably the most constant symptom, is subject to frequent variation. In place of the typical lumbar pain radiating downward and forward along the course of the ilio-inguinal nerve, this symptom may be more or less localized and even referred anteriorly to a point above or below the level of the navel. This is of importance in the differential diagnosis of renal calculus from inflammatory conditions of the gall-bladder, duodenum and pancreas, and strongly emphasizes the need of X-ray examination in these baffling conditions. Rarely pain is conspicuous by its absence. In one such instance recently observed, the patient's attention was attracted by a hæmaturia (Case V). As is well known this symptom, especially in those beyond middle age, strongly suggests malignancy of the bladder. Moreover, at any age, it may be the first indication of a hypernephroma. Fortunately for the patient (aged fifty-eight) investigation of the bladder proved normal while an X-ray of the lumbar region showed a well-defined calculus apparently in the parenchyma of the kidney. The discovery of a renal calculus may be entirely accidental. This is well illustrated in the following history. Case XIII, a man of thirty-five apparently in perfect health applied for life insurance. The urine on microscopic examination was found to contain a small amount of pus which on cystoscopic examination was found to issue from the left ureter. An X-ray then taken showed the shadow of a calculus the size of a lima bean which was successfully removed from the kidney parenchyma.

While renal calculi may thus form without symptoms, the writer believes that this is a very much less frequent occurrence than the corresponding formation of gall-stones.

Rarely pain due to a renal calculus is referred to the opposite kidney. This rare variation, usually considered to be due to some abnormality in the reflex path, is well illustrated in Case XII, in which a different explanation is suggested by the subsequent history of the patient. After the removal of the calculi from the affected kidney the pain persisted at intervals on the right side, occasional X-ray and ureteral catheter examinations proving negative until four years after the operation when multiple calculi were demonstrated

in a radiogram. The explanation referred to is that the right-sided pain was due to the irritation of the urine of the right kidney even before any recognizable precipitation of its mineral constituents had taken place. The exact nature of the change in the chemical composition of the urine responsible for the pain it is impossible to state.

The surgical treatment of renal calculus depends upon their number, location, whether the lesion involves one or both kidneys and the condition of the kidney itself. Single or multiple calculi in the pelvis are most easily and safely removed through an incision in the posterior pelvic wall. This method of approach has gradually superseded the removal of calculi in this location through the kidney parenchyma for the danger of a persistent urinary fistula after the former proceeding proved largely imaginary while the risk of post-operative hemorrhage from divided kidney tissue, occasionally of such an extent as to require immediate nephrectomy, is obviously avoided. The exposure and removal of calculi in the renal parenchyma is possible only after division of the overlying kidney tissue. In this group of cases, the X-ray has proved of the greatest value in determining the number of calculi and their approximate position. This information ordinarily directs the point of attack and defines the limit of the operation so that unnecessary exploration is avoided. The procedure is, however, not always so simple for, as in the case of fractures, the interpretation of X-ray plates is occasionally misleading and confusing, especially when multiple calculi overlap. If for this or any other reason the locating of the calculus or calculi is difficult, valuable assistance is given through the bimanual palpation of the kidney in the course of the operation. In this manœuvre the kidney is gently compressed from above downward between the tip of the little finger inserted through an incision in the posterior pelvic wall and the index finger of the same or opposite hand on the external surface of the kidney. This method of palpation, first advocated by the writer in a paper published in 1906, has proved most serviceable. Except in those cases of long standing calculi in which fibrosis has developed, the cortex of the kidney so compressed feels both thin and soft, and calculi, even of small size can easily be felt. The nature and direction of the incision of the kidney tissue through which the calculus is to be removed depend upon its character and size. Large branching calculi are best approached through an incision longitudinal along the convex border of the organ. For small calculi, the writer prefers an incision at right angles to the long axis of the kidney. In both it is important to remove the calculus without fracture in order to avoid the possibility of recurrence from a small fragment left *in situ*. After the removal of the calculus the divided kidney tissue is best approximated with one or more mattress sutures of catgut. Nephrectomy is always justified in calculous pyonephrosis, and in cases in which the kidney parenchyma is studded with a large number of calculi provided that an X-ray examination shows no calculi in the remaining kidney, and that satisfactory renal sufficiency can be demonstrated in the urine

collected from that organ by ureteral catheterization. If a nephrectomy is to be done, it is well to remember that the pedicle of the affected kidney may have been shortened by the contraction of perinephritic tissue associated with long standing inflammation of both the infectious and non-infectious types, and that, especially on the right side, which normally has a shorter pedicle, a subcapsular removal of the organ may prove the safest measure. When both kidneys are involved it may be difficult to determine the appropriate treatment especially if the calculi are multiple. In general, the removal of the calculi at separate times may be attempted if they appear to be limited to the kidney pelvis or if, in the parenchyma, their number is sufficiently small to justify a reasonable expectation of operative success. Nephrectomy of the more involved kidney is rarely justifiable except for pyonephrosis and then only when an adequate renal sufficiency of the remaining organ can be demonstrated.

In general the immediate operative results in cases of renal calculus are very satisfactory, especially in the removal of calculi situated in the pelvis only. This operation causes little if any disturbance in the function of the kidney, the urine not being perceptibly diminished in quantity and containing during the first twenty-four hours a considerable quantity of clotted blood. During the first day or two there is a little discharge of urine in the dressing, which after that interval entirely disappears. That the operation is not devoid of risk, however, is shown by two fatalities, one in the writer's series of cases and the other in that of a skilled and experienced colleague. In the former instance, the removal of the calculus through an incision in the kidney pelvis, a sudden rise of temperature appeared after an uneventful convalescence of eleven days and varying between 105 and 108°, continued for five days until the patient's death. The wound drained satisfactorily during the entire period and no subjective or objective symptom could be elicited to account for the unusual course. Unfortunately no autopsy could be obtained. The other case, seen in consultation by the writer, occurred in a strong robust adult of twenty-one. Twenty-four hours after operation, shock suddenly developed with death on the following day. The removal of the calculus through a pelvic incision had been quickly done with a minimum of kidney manipulation. An autopsy showed no hemorrhage, no involvement of the kidney and no lesion that could account for the unfortunate result.

While, as has been stated, no immediate change in the function of the kidney from which the stone has been removed is apparent, the possibility of gradual development of diminished excretory power of the affected organ must be taken into account. Routine post-operative ureteral catheterization, continued for a sufficient length of time, would unquestionably decide this question. It has only been done in a few of the writer's cases and usually some months after the removal of the stone in which the recurrence of lumbar pain pointed to possible recurrence. In these scattered instances this procedure showed symmetrical kidney excretion. Another although uncommon proof of the persistence of normal kidney activity is furnished by the post-operative renal fistula. In Case VI such a fistula discharging a considerable amount of

urine persisted for over a year after a removal of a calculus in the pelvis through an incision in the kidney tissue.

The writer wishes to emphasize the need of careful investigation of the chemistry of the urine of the affected kidney both before and after operation, comparing the respective analyses with each other and with the urine of the normal side in order to discover evidence that, however, imperfectly, may indicate the character of the changes in the metabolism that predispose to, if they do not actually cause, the formation of calculi.

No part of the subject is more interesting than the consideration of recurrence after operation. The complete removal of one or more calculi from the kidney parenchyma or pelvis relieves the patient of one or more foreign bodies, without in any way affecting the cause of their formation. It is not strange, therefore, that calculi recur. Perhaps it is strange that recurrence is not more frequent. Recurrence while more common after removal of calculi from kidney parenchyma may also occur after the removal of even a single calculus from the pelvis. To this class belongs Case XI, in which after a succession of recurrences in different locations a terminal infected pyonephrosis developed, requiring nephrectomy. The writer is especially apprehensive of recurrence after removal of calculi in the parenchyma, for the reasons that in this situation, calculi are so frequently multiple, and that one or more may be so small as to escape detection not only by means of the X-ray but by careful palpation of the kidney itself in the course of operation, Strictly speaking such a condition is not a recurrence, but an excusable failure to detect calculi in the early stage of their formation. The writer believes, however, that a true recurrence may develop due to the excusable failure to relieve the predisposing and exciting causes of altered metabolism. That the parenchyma, after the removal of calculi, may remain free from recurrence has been the writer's experience in half a dozen patients, who have shown no subjective symptoms or visible urinary changes for periods of from 2 to 16 years. Such evidence is obviously faulty without the support of X-ray and ureteral catheterization. However, the patient free for 16 years was accepted as a good insurance risk much, it must be confessed, to the surprise of the writer. The constant shifting of urban population is responsible for the failure to trace other patients operated on for this condition, especially those treated in hospital wards. The fact, however, that few cases of recurrence in patients operated on by other surgeons, have been encountered, indicates at least that recurrence on the whole is uncommon. Nevertheless it must be conceded that a complete removal of all calculi, even of those limited to the kidney pelvis, does not by any means insure a permanent cure. In spite of measures to prevent recurrence, such as the regulation of the diet and the use of a sufficient quantity of alkaline salts to maintain a neutral or slightly alkaline urine continued indefinitely, recurrence may occur. In this respect renal calculus is analogous to gastric ulcer in which, no matter how radical the operative treatment, even the most careful subsequent hygienic and dietetic measures fail at times to prevent recurrence.

While the necessity for the radical removal of renal calculi can never, in

all probability, be avoided, future progress in the treatment of this condition surely lies in the development of the knowledge of those changes of tissue metabolism which predispose to their formation and to the discovery and adoption of suitable measures to regulate and maintain normal metabolic changes in the tissue cell.

CASE REPORTS

CASE I.—Female, fifty-two. History of dull lumbar pain, especially on walking, thought to be due to movable kidney. After an attack of acute appendicitis the pain disappeared until two and one-half years before admission to the hospital, since when it has persisted until the present time. There has been increased frequency of micturition with occasional hæmaturia. A calculus, found on X-ray examination, rough in character and free in the kidney pelvis, was removed by pyelotomy with relief of the local symptoms.

CASE II.—Adult male. Several similar attacks to the present one for the past five years. Present attack began to-day, before admission to the hospital, with vomiting, chills, headache, bloody urine and pain in the left lumbar region. There was also increase in frequency of micturition. On operation a stone, three-quarters of an inch in diameter, was found in the pelvis of the left kidney, concealed by the approximation of the kidney poles, curved over by the contraction of peri-renal connective tissue. The kidney was delivered after the removal of the twelfth rib. The stone was felt but could not be attacked through the pelvis, owing to the overlying kidney tissue. A silk ligature was passed upward through an incision in the pelvis through the overlying kidney tissue which was then divided by a sawing motion. The calculus was then removed and the divided kidney tissue which bled profusely was easily controlled by suture.

CASE III.—Female, forty-three. History of frequent micturition for eight or nine years with dragging pain in the legs. Five months ago was said to have voided gravel. Two weeks after an uncomplicated removal of an intraligamentous cyst on the right side severe pain developed on the left side ileocostal space, radiating to bladder with local tenderness and constitutional symptoms of fever. Gradual subsidence in three days. Ten days afterward, onset of attack with sudden sharp pain over the right kidney with nausea, vomiting, marked diminution in the quantity of urine and the formation of a mass in the right hypochondrium the size of an orange. Catheterization of the left kidney showed a normal condition, while that of the right showed obstruction four inches above the bladder.

On operation a pyonephrosis was found with calculi in the sac and the ureter four inches below the brim of the pelvis was found to be completely blocked by a mass of calculus detritus. The purulent material had a distinct colon odor. Nephrectomy was done. There was no apparent connection between the occlusion in the ureter and the intraligamentous cyst which was excised three weeks before the nephrectomy. Recovery.

CASE IV.—Female, twenty-four. In September, 1910, stone was removed from the pelvis. One month after operation increased frequency, with burning pain, was noticed and has continued for the past six months. For the week prior to admission there was a recurrence of the old lumbar pain which existed prior to the removal of the calculus, with purulent intermittent urine but no blood. X-ray showed two calculi in the parenchyma. Nephrectomy. Examination of the kidney showed multiple calculi in the parenchyma with evident fibrosis, and, on microscopical examination, tuberculosis with degeneration of the parenchyma.

CASE V.—Male, thirty-two. Fourteen months ago, left kidney was explored by another surgeon after three attacks of severe stabbing pain in the left flank radiating to the left groin and scrotum. The operation was terminated uncompleted

on account of hemorrhage. Five months later a recurrence of the pain with abscesses in the scar. A large branching calculus in the pelvis of a pyonephrotic kidney which had been disclosed by an X-ray demanded a sub-capsular nephrectomy, from which the patient recovered.

CASE VI.—Male, fifty. For the past ten years patient has had attacks of pain, passing of stones, of increased frequency of micturition with burning sensations at the end. Three stones found on X-ray, were removed by nephrotomy from the right kidney pelvis to the wall of which they were adherent. Kidney tissue was sutured. Several months after the operation, similar symptoms developed on the left side which continued for two years, when through a left nephrotomy a stone was removed from the parenchyma of the left kidney to which it was so adherent that it was fractured in its removal. Following this operation the patient developed a lumbar urinary fistula which continued to discharge for nine months. After the second operation catheterization of the right ureter showed normal urine and examination with the X-ray failed to disclose any calculus. One year later a second catheterization and X-ray showed a normal condition of both kidneys.

CASE VII.—Male, thirty-two. Pain referred for almost four years to the right upper quadrant of the anterior abdomen, coming on in various attacks especially after exercise. Fourteen months before admission a stone was removed from the right kidney at Rio Janeiro. (The patient was shown the calculus.) Three weeks later another severe attack of renal colic and, on admission to the hospital, X-ray disclosed the presence of a calculus with a rough surface which was readily removed from the kidney pelvis. The kidney was invested in dense adhesions.

CASE VIII.—Female, twenty-nine. Dull aching pain terminating in the formation of a large hydronephrotic sac which when opened contained a small piece of gravel in the pelvic mouth. As the left ureter had not been found on cystoscopy no nephrectomy was done. Subsequently the left ureter was catheterized and the left kidney found normal. A right nephrectomy was then done, disclosing a large number of calculi in the old hydronephrotic sac.

CASE IX.—Male, twenty-nine. History of lumbar pain for the last twelve years with several attacks of sharp colic. During the eight months preceding admission to the hospital, pain had become much worse.

Operation showed one calculus in the pelvis and a second one in the parenchyma. The former was removed through an incision in the pelvic wall, the latter by nephrotomy with suture of kidney tissue.

CASE X.—Male, twenty-two. History of ten years pain of sudden paroxysmal character with no urinary symptoms. A nephrectomy was done for multiple calculi with loss of kidney tissue. In addition patient suffered from pulmonary tuberculosis. The left kidney was normal. Satisfactory recovery.

CASE XI.—Male, twenty. History of pain in right flank radiating to penis and testis, of four months duration. A stone was found in kidney parenchyma a short distance above the pelvis but not communicating with that cavity. It was removed through a vertical incision in the kidney tissue. Bimanual palpation failed to disclose other calculi. Six months later X-ray examination showed no stone in either kidney or in the pelvic ureter.

Three years after operation, pain appeared in the right flank radiating into the right testis. Patient frequently noticed the passage of thick white muco-pus in the urine. X-ray showed a large dense shadow on the right side of the pelvis in the line of the ureter. Ten days later a large calculus was removed by the anterior extraperitoneal route from the right ureter near the pelvic brim. Six weeks later the patient required a right nephrectomy for a condition of pyonephrosis, no stone being found in the kidney.

CASE XII.—Female, thirty. Four years ago patient first noticed pain on the right side radiating first to the lumbar region and then to the mouth of the urethra. X-ray showed a number of calculi in the left kidney and none on the right side, the side of the pain. These were removed by both pyelotomy and nephrotomy from the pelvis and kidney parenchyma.

Six months after operation, patient still complained of pain on the right side. Both urethral catheterization and X-ray proved negative.

Three years after operation, patient still complains of pain on the right side, coming on in attacks similar to those experienced before the calculi were removed. The patient was confined to bed for a time without evident change in the character of the urine, the passage of which was noticeably increased during the day. Again X-ray examination was negative. The result of catheterization of the ureters was as follows: The urine from the right kidney was alkaline. It contained small numbers of both red and white blood-cells. The amount passed during the time of observation was two c.cm. The urine from the left kidney was acid with the same cellular content as the right. The amount passed during the period of observation was 25 c.cm. The catheter passed easily up both ureters without sign of obstruction. The flow from the left was free and normally intermittent. That from the right was delayed and only appeared after the injection of saline solution. Neither urine was macroscopically abnormal. With the catheters *in situ* an X-ray of the urinary tracts was negative.

Fifty-three months after operation there was no change in the subjective or objective symptoms.

Fifty-nine months after operation.—For the past month patient has suffered from attacks of pain on the right side with chills and fever. An X-ray examination showed a large branched calculus in the pelvis of the left kidney with two adjacent smaller stones and one on the right side (the first appearance of a calculus in this kidney) somewhat smaller and irregular. During the following six months, patient passed several small calculi per urethram. Patient still under observation.

CASE XIII.—Male, thirty-six. No previous indication of renal calculus. On examination for life insurance a small amount of pus was discovered in the urine. This led to a cystoscopic examination in which the urine from the left ureter was found to be cloudy. X-ray examination then disclosed the shadow of a calculus the size of a lima bean in the parenchyma of the left kidney which was successfully removed. The patient subsequently obtained life insurance.

CASE XIV.—Male, forty. Patient gives a history of occasional attacks of lumbar pain of short duration becoming of late more frequent extending forward and downward. Persistent tenderness in the lumbar region has followed these attacks of pain. During the attack the patient has noticed blood in the urine.

On operation a calculus was removed from the pelvis of the kidney through an incision in the posterior pelvic wall. Wound drained in the usual manner. Convalescence uninterrupted for eleven days when without discoverable cause patient developed a temperature of 104°. This continued without marked remission for four days, varying from 104 to 108°, when the patient died. There was no subjective or objective symptom in the abdomen or wound to account for this unusual clinical course. Unfortunately no autopsy was permitted.

CASE XV.—Male, fifty-nine. Patient always well and strong. Recently without warning patient noticed blood in the urine. This was repeated occasionally and in varying quantity for a fortnight. There was no pain or discomfort of any kind. The hæmaturia was the sole symptom. An X-ray of the kidney showed a small concave more or less pointed calculus. No operation, patient being kept under observation.

OSSIFICATION IN KIDNEY STONES ATTACHED TO THE RENAL PELVIS*

By Dallas B. Phemister, M.D.
of Chicago, Ill.

There exists a tendency to ossification in the organs of the urinary tract, under certain experimental and pathological conditions, which is greater than that in any other system of organs. Some of this ossification appears to be related to the direct and continuous action of the urine upon altered tissue bordering on the urinary channel. That in the kidney results from the fact that it is an end organ, and interference with its blood supply is followed by degeneration, which creates a field for calcification and ossification that is more favorable than that produced in other organs. Experimentally, bone has been produced in ureter, bladder and kidney. Strauss [1] repaired defects in ureters in dogs with pedunculated flaps of fascia and found that in every instance a layer of bone formed in the portion bordering on the lumen, converting it into a rigid tube. Neuhof [2] repaired defects in the bladders of dogs by transplantation of fascia lata and found regularly that the portion of graft bordering on the lumen became ossified. Calcification was found to begin six days and ossification seventeen days after operation. There was no associated stone formation nor incrustation of bony plaque bordering on the urinary channel in either set of experiments. An epithelial lining grew from the margins and soon covered the entire bony surface, so that in the older experiments no bone bordered on the lumen. The pelvis of the kidney of the mink [3] and of the coatimundi [4] is not infrequently invaded by the worm eustrongylus gigans, interfering with drainage and producing hydronephrosis with reduction of kidney substance. When these changes are marked, ossification occurs regularly in the thickened fibrous walls of the pelvis. Sacerdotti and Frattin [5] were the first to show that ligation of the renal artery in rabbits is followed by calcification and ossification in the necrotic kidney. Asami and Dock [6] ligated both renal artery and vein of the rabbit's kidney and found that bone formation began independently of calcification in the loose vascular connective tissue close under the transitional epithelium of the calyces. Bone later formed in the calcified areas through erosion of the lime plaques and deposition of lamellæ by cells derived from fibroblasts.

In man, ossification in the urinary tract has been reported only in connection with the kidney and but rarely. However, calcification in the kidney is a common finding, especially in the pyramids, in acute destructive kidney lesions, as bichloride of mercury poisoning, and in old age, osteomalacia, osteitis fibrosa and metastatic carcinoma of the bones, in which conditions

* Read before the American Surgical Association, May 31, 1923.

there is mobilization of a considerable part of the stored-up calcium of the body. Localized calcification occurs in infarcts and degenerated inflammatory areas, and there may be subsequent partial replacement of the lime salts by bone. I have seen partial replacement by bone of calcified areas in tuberculosis of the kidney and in hypernephroma.

A search of the literature fails to show a recorded instance of ossification in connection with kidney stone, either in the pelvis of the kidney or within

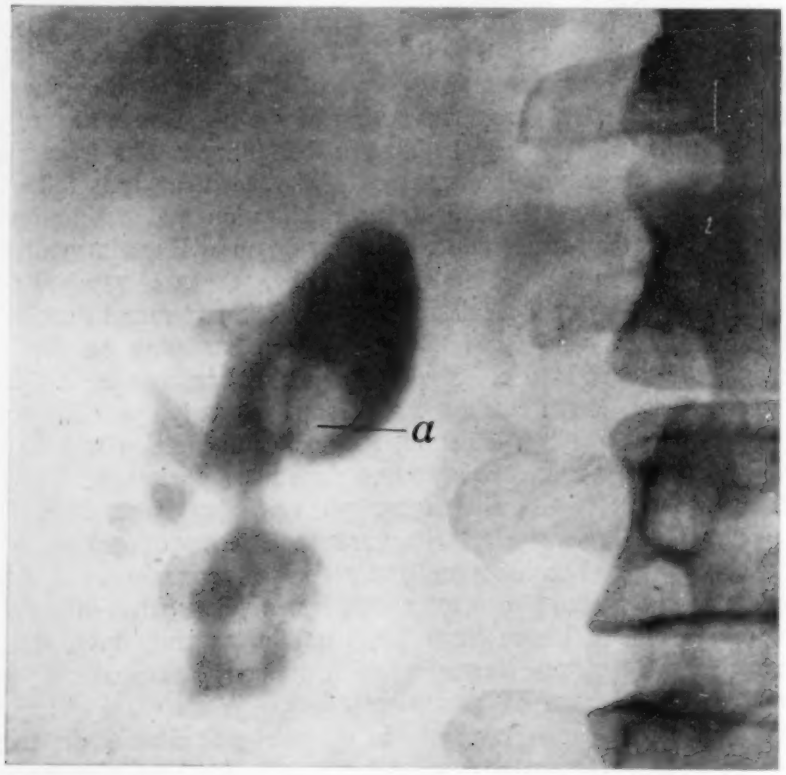

FIG. 1.—Case I. Röntgenogram showing circular area (*a*) of slight density in stone.

the stone itself. Also, there seems to be no record of stone attached to the pelvis of the kidney, either by a pedicle or as an incrustation on the pelvic wall. The three stones here to be described were attached to kidney lining and were composed partly of living bone.

CASE I.—J. M., male, age thirty-six, entered Presbyterian Hospital, September 28, 1921. He gave a history of attacks of pain and soreness in the left kidney region extending over a period of twenty-five years. Three months previously there was a severe attack of renal colic, and since then the urine has been slightly cloudy at times. Blood was noticed first two days ago. Examination revealed slight tenderness in the left kidney region. A röntgenogram showed numerous stone shadows in the region of the left kidney (Fig. 1). There was a large, dense, branching shadow in the region of the pelvis. There was a circular area of very faint density in the lower portion of this dense shadow, which comprised

one-half of its diameter. The urine was acid in reaction and showed many pus cells and erythrocytes. On ureteral catheterization by Doctor Herbst, clear urine was obtained from the right kidney and cloudy urine, containing many pus cells and erythrocytes, from the left kidney. Cultures of the urine from both kidneys were negative. The reaction of the specimens of urine from the two kidneys was not determined separately. Left nephrectomy was performed by Doctor Bevan, October 3, 1921.

Pathologic Examination.—There was a small amount of perinephritis. On section of the kidney there was moderate dilatation of pelvis and calyx and reduction in height of pyramids. There were several small stones in the calyces, especially of the lower portion; and one large oval, branching, mulberry stone in the pelvis and extending into the upper calyx. Stone 1. Pelvic wall was ulcerated in places from contact with stone. The dimensions of the stone were 4.0 cm. by 2.5 cm. by 2.0 cm. After removal it was discovered that a fibrous pedicle ran into the stone at the fork. This had been broken before it was observed and its exact point of attachment to the pelvis was not located with certainty, but it was probably on the portion of pyramid that lay in the fork of the stone. The stone was broken and found to be composed in its lower portion of a grayish nucleus comprising one-half of its diameter and extending to the surface at the point where the pedicle entered. (Fig. 2.) This portion had the appearance and consistency of spongy bone. The rest of the stone was composed of dense superimposed lamellæ, which were dark brown in its peripheral portion and grayish to light brown in its deeper portion, where it came in contact with the central nucleus. A röntgenogram of the reconstructed stone (Fig. 3) showed that the area of slight density corresponded to the nucleus resembling bone. Microscopic examination of a section from the nucleus showed it to be composed of living spongy bone containing marrow, fat, loose fibrous tissue and capillaries in its cancellous spaces (Fig. 4). A section of a decalcified portion at the line of junction of bone and stone showed, along one side of stone, a layer of crystals difficult to identify but apparently mostly calcium oxalate. They were invaded by connective tissue in which bony trabeculæ had formed (Fig. 5). Near the base of the pedicle, white fibrous tissue filled a considerable area

FIG. 2.—Case I. Drawings showing stone with pedicle and in cross section with interior of bone.

of the nuclear space and on one side bordered directly on stone, which was made up of a layer of calcium phosphate crystals. Chemical analysis of a portion of the stone showed the inorganic elements to be composed of calcium oxalate 97 per cent. and calcium carbonate 3 per cent. The inorganic elements comprised 96 per cent. of the total dried calculus examined. There were traces of magnesium and phosphorus, but the murexide test for urates was negative. Apparently the periphery of the bone was in contact with an inner layer of stone, composed mostly of calcium oxalate in some portions and of calcium phosphate in others.

FIG. 3.—Case I. X-ray of stone showing lamination and area of slight density corresponding to bone.

The order of development of the pathological picture presented cannot be definitely stated, but at the time of examination the stone was attached to the pelvis by a fibrous pedicle and its interior was composed of a large nucleus of bone, which, from microscopic examination at the line of junction, had been gradually replacing the stone. It is difficult to say whether the stone was attached from the beginning at a point of break in the mucous membrane of the renal pelvis and grew about the tip of a fibrous pedicle, which itself had already calcified and later gradually underwent metaplasia into bone, or whether the stone formed free in the renal pelvis and by its large size and roughened surface eroded the pelvic lining and became attached secondarily by an invading fibrous pedicle, the tip of which in turn ossified by metaplasia and replaced bone.

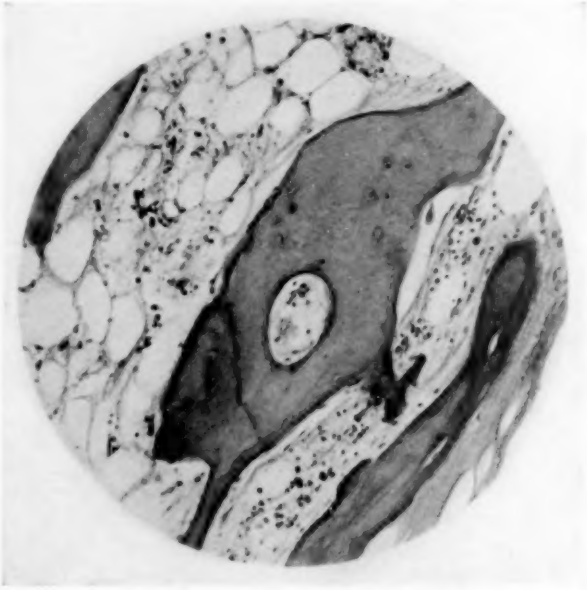

FIG. 4.—Case I.—Photomicrograph of bone.

CASE II.—J. P., male, age twenty-four, entered Presbyterian Hospital, January 15, 1923, giving a history of occasional attacks of pain in the right renal region during the past eleven years. During the past two months there had been increased frequency of and burning on urination. Physical examination was negative, aside from moderate tenderness and rigidity in the right kidney region. A röntgenogram (Fig. 6) showed several shadows of stones in the right kidney. There was one large, dense, branching shadow in the region of the renal pelvis. No definite area of lessened density could be made out within it. The urine was alkaline and

contained many pus cells, triple phosphates and amorphous urates, and catheterized specimens showed pus from the right kidney, but none from the left. Staphylococcus was grown in cultures of urine from the right kidney. The reaction of the urine obtained separately from the kidneys was not determined, but since the bladder was found normal and its urine alkaline, the urine from the right kidney must have been alkaline. Right nephrectomy was performed by Doctor Bevan, January 26, 1923.

Pathological Examination.—There was some perinephritis and a slight cystic bulging of a portion of renal cortex opposite the pelvis. On section of the kidney, the pelvis was found to be slightly dilated and the calyces markedly so. At the middle of the organ there was complete destruction of a lobule of kidney with a thin-walled sacculation of a calyx extending to the surface (Fig. 7). There were several small stones in the dilated calyces and a large branching one occupying most of the pelvis. Stone 2. Its middle portion was roughly granular and dark brown on one side, but the rest of its surface was smooth and sand colored. The lining of the pelvis was thickened and grayish-red in color. A small, short pedicle was observed to run from the side of the pelvis and to be attached to the middle portion of the stone at the margin of the dark surface. It was cut and the stone removed. It was then observed that pelvic lining coming in contact with the middle portion of the stone was lightly granular, and microscopic examination of an excised portion showed ulceration, round-cell infiltration and absence of epithelial covering. The pedicle of the stone sprang from this eroded surface.

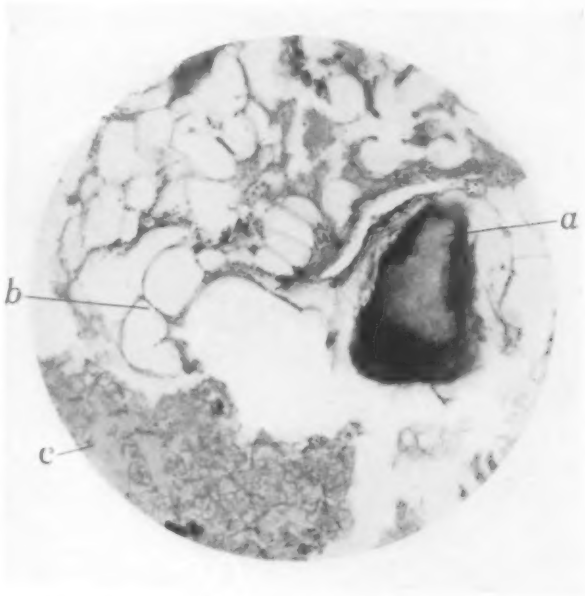

FIG. 5.—Case I. Photograph of junction of stone and bone; (*a*) is stone composed of crystals, (*b*) is invading capillaries and (*c*) is trabecula of newly formed bone.

A röntgenogram of the stone (Fig. 8) showed a superficially located area of slight density about the size of a wheat grain at the point of entrance of the pedicle. Suspecting that there might be bone filling out this area of slight density, I gouged out its contents and had them sectioned after twelve hours of decalcification in five per cent. nitric acid. Microscopic examination showed spongy bone with fibrous tissue, bone marrow and capillaries filling its cancellous spaces. Small portions of stone were also present, some of which were attached to the bone, showing the undisturbed line of junction. The attached fragments appeared to be composed of oxalate, phosphate and carbonate of lime. The stone was being absorbed by fibroblasts in a rich capillary network and directly replaced by bone (Fig. 9). The stone was then broken and its middle portion found to consist of a hard, dark brown, slightly laminated, irregularly spherical mass,

which came to the surface on one side. Deposited on this was a sand colored, soft material which formed the two large, irregular poles. The pedicle had entered at a point where there was only a very thin sandy deposit on the dark central mass. The pocket occupied by bone was mainly in the peripheral part of the dark portion. The central nucleus of this area, which was the primary deposit, was some distance away from the bottom of the pocket, so that the bone could

FIG. 6.—Case II. Röntgenogram showing stones but no discernible ossified areas.

scarcely be regarded as the nucleus or starting-point of the stone. Chemical analysis of the dark portion gave calcium phosphate 10.17 per cent., calcium carbonate 10.57 per cent. and calcium oxalate 79.26 per cent. The sand colored portion gave calcium phosphate 86.35 per cent., calcium carbonate 3.57 per cent. and calcium oxalate 10.08 per cent. Both portions contained traces of magnesium and gave a negative murexide test for uric acid.

This stone gave the appearance of having been invaded by the pedicle, which sprang from pelvic wall devoid of epithelial lining and had made a pocket in the periphery of the portion composed mainly of calcium oxalate. Bone had formed in the pocket as the stone was gradually absorbed.

On the inner wall of the sacculation in the cortex of the middle portion of the kidney, there was a flat mushroom-shaped stone about 1 cm. in diameter, attached by a short, broad pedicle. Stone 3. A section for microscopic examination was cut through the stone and pedicle, including 1 cm. of the wall of the saccule to either side. The pedicle consisted of a broad fibrous elevation of the

wall and was capped by a layer of stone (Fig. 10). The line of junction of stone and bone was distinct. The stone was of a uniform light brown color and was not laminated. To facilitate decalcification, the stone was broken away, leaving only a thin, irregular layer attached to the pedicle. Microscopic examination of the section showed the wall of the saccule away from the pedicle to be composed almost entirely of fibrous tissue. The inner lining was formed by inflammatory tissue, consisting mainly of round cells with a few lymphocytes and plasma cells. There were no epithelial cells present. The pedicle was composed of mature connective tissue in its outer portion. Its inner portion consisted of connective tissue showing some degeneration, in which there was a heavy deposit of lime salts, which increased somewhat in amount as the junction with the stone was approached. The morphology of this deposit was similar to that of calcified areas found elsewhere in the body (Fig. 11). They have been found to consist of approximately 85 per cent. of calcium phosphate and 15 per cent. of calcium carbonate, and that is probably the composition of this deposit.

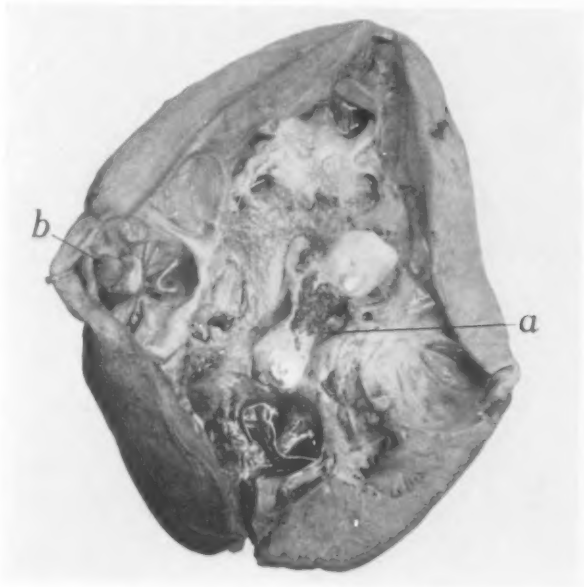

FIG. 7.—Case II. Photograph of bisected kidney, showing large stone in pelvis, attached by pedicle (*a*) and small mushroom-shaped stone (*b*), attached to wall of sacculation.

At the junction of pedicle and stone there are numerous small islands of bone, which have been laid down in the calcified areas. This is quite similar to the ossification which is seen in calcified areas in other parts of the body. The attached portions of stone are seen under the high power to be composed of layers made up of thread-like framework in which are deposited small granules and amorphous masses, which are lime salts, not easily identified, but presumed to be largely calcium phosphate and oxalate (Fig. 12). Chemical analysis showed the inorganic constituents to be calcium phosphate 86.39 per cent. and calcium oxalate 13.61 per cent. There was no calcium carbonate, and the murexide test for urates was negative.

This is the youngest stone of the three and shows the very beginning of the process of ossification in its pedicle. There is marked calcification in the pedicle, but all of the spicules of bone seem to have formed in the base of the stone, where connective tissue and blood-vessels have invaded it from the pedicle. It seems probable in this case that calcification occurred first in the wall of the sac, which was followed by the deposition of stone upon its free surface, and this in turn by ossification in the base of the stone.

There is a great deal of resemblance between bone, calcified areas and urinary stone. All three are composed of a crystalloid substance or substances deposited in an organic and mainly colloidal framework. Bone consists of lime salts deposited in a definitely constructed living connective-tissue framework. The proportions of lime salts and framework remain constant, being 60 and 40 per cent., respectively. Calcified areas consist of lime salts deposited in a framework of almost any degenerating or degenerated tissue of the body, and there is no definite relation between the amounts of each. The lime salts are the same in both calcification and ossification, consisting of calcium phosphate and calcium carbonate in the almost constant proportions of 85 per cent. for the former and 15 per cent. for the latter. The composition of urinary stones is more variable in every respect than that of bone or calcified areas. Crystalloidal and colloidal deposits may be composed of one or more of a number of substances, any of which may vary greatly in amount. The crystalloidal deposits may be organic, as uric acid, urates, calcium oxalate, cystin or xanthin, or inorganic, comprising chiefly the carbonates and phosphates. Those comprising the three mixed stones in which ossification occurred were calcium oxalate, calcium phosphate and calcium carbonate. The framework of stones consists mainly of urochrome (held not to be a colloid by Lichtwitz[7] and others), nucleic acid and chondroitin sulphuric acid. The chemical nature of the framework in these stones was not determined.

FIG. 8.—Case II. Röntgenogram of large stone, showing slight density at (*a*), corresponding to point at which bone was found.

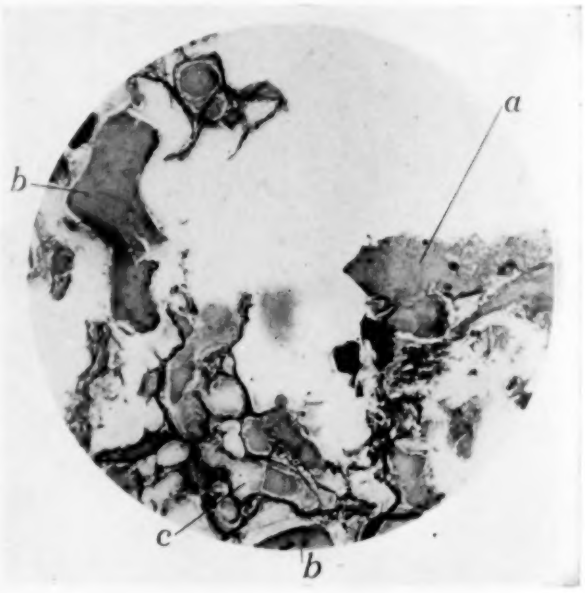

FIG. 9.—Case II. Large stone. Photograph at junction of stone and bone, showing calcified areas (*a*) being absorbed and replaced by bone (*b*). Capillaries numerous (*c*).

The question arises if there is a common factor in the urinary tract which influences the three processes, ossification, calcification and stone for-

mation. It is the general belief that both ossification and calcification occur normally in tissues that have an excess of acid present. The two stones here found to contain a considerable amount of bone were composed very largely of calcium oxalate, and calcium stones form in acid urine. In the large stone of Case II, consisting of a primary oxalate portion and a secondary phosphate and carbonate portion, all of the bone was in the oxalate portion, suggesting that it began to form while the urine was acid. The second phosphate deposit was added after the urine became alkaline. Since the urine is mildly acid, due to the presence of acid sodium phosphate, and bathes the field along the urinary channel in which these processes start, it should be considered as a possible causative factor.

Strauss attributed the ossification in fascial flaps, used to reconstruct the ureter in dogs, to the direct action of the acid urine upon the fascia. Neuhof considered the calcification and subsequent ossification in the fascial transplant into the bladder to be in the nature of a functional response to strengthen the weakened portion of wall. He thought the lime salts came from the urine and were deposited in the degenerating fascia. Their presence in turn stimulated the surviving elements of the graft to change into bone, which is the most powerful barrier. Dr. Howard Dabbs and I repeated Neuhof's experiments on dogs and substantiated his findings, but we have interpreted the calcification and ossification differently. Dogs' urine is acid. The rabbit, which has alkaline urine, was used by us in four experiments, and the animals were killed in from ten to forty days. Calcification and ossification failed to occur in any of them. The sheep, which also has alkaline urine, was used in a seven weeks' experiment, and bone failed to form. We attempted to keep the urine continuously alkaline in a number of dogs with fascial transplantation into the bladder, by means of diet and administration of alkalies, but found it impossible of achievement. Bone formed in the transplant in every experiment, despite the fact that the urine was alkaline for certain periods of each day. These observations support the view that the acid reaction of the urine has something to do with the bone formation. As previously stated, all calcified areas have been found to contain about 85 per cent. of calcium phosphate and 15 per cent. of calcium carbonate, which represents their relative solubility in the blood, and precipitation of salts from a solvent occurs according to their relative solubility. The salts are carried in the blood mainly in colloidal solution and they are found in the urine in a different proportion than in the blood, the

FIG. 10.—Case II. Drawing of small mushroom stone.

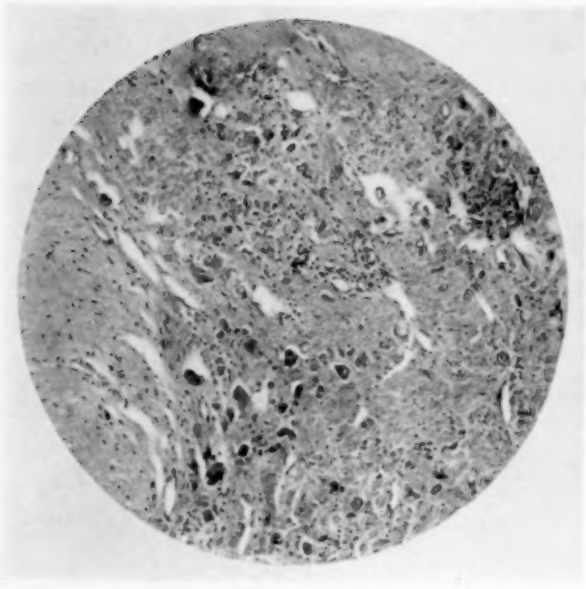

FIG. 11.—Case II. Photomicrograph. Calcification in pedicle of small stone.

calcium carbonate being relatively much lower. Therefore it seems logical to assume that the lime salts are deposited from the lymph or blood in the portion of transplant bordering on the lumen, where nutritional conditions are poorest, necrosis is greatest, and acidity increased by contact with the acid urine of the bladder. Ossification follows as a sequence to the calcification, and is also augmented by the urine.

The findings in stones 1 and 2 suggest the following pathogenesis: Oxalate stone 1 and the primary oxalate portion of stone 2 formed in acid urine. They grew to a size where they became fixed in the pelvis. Their roughly granular surfaces produced pressure erosion of pelvic epithelial lining. Connective tissue grew out and invaded a pocket of the stone. The lime salts of the stone and the acid reaction of the urine with which the invading pedicle came in contact produced metaplasia into bone with resultant osseous metamorphosis in the calculus. No calcification was seen in the invading connective tissue of these stones. After infection and alkalinization of the pelvic urine in Case II there was secondary stone formation, consisting mainly of calcium phosphate.

FIG. 12.—Case II. High-power of base of stone, showing framework and calcium deposits with invasion of bony trabecula (*a*).

The findings in stone 3 suggests a different process of development and to some extent contradict that given for the first two. The sacculation apparently occurred first, and calcification took place in a portion of the wall devoid of epithelium. Lime salts from the urine were then deposited on it in the nature of an incrustation, such as is seen upon a non-absorbable suture or other foreign body projecting into the urinary tract. A small amount of ossification took place in the base of the stone, where it joined the partially calcified pedicle. Condition easily overlooked.

I am indebted to Miss Mary E. Mavee of the Sprague Foundation, University of Chicago, for the chemical analyses of the stones.

LITERATURE

[1] Strauss, Alfred A.: An Artificial Ureter Made from the Abdominal Wall. Surg., Gynec., and Obst., Jan., 1914, vol. xviii, p. 78.

[2] Neuhof, Harold: Fascia Transplantation into Visceral Defects. Surg., Gynec. and Obst., April, 1917, vol. xxiv, p. 383.

[3] Weinland: Arch. f. Naturgeschichte, 1859, vol. i, p. 283.

[4] Leuckart: Die Parasiten des Menschen, vol. ii, p. 396.

[5] Sacerdotti and Frattin: Archiv. f. path. Anat., 1902, vol. clxviii, p. 431.

[6] Asami, G., and Dock, W.: Experimental Studies on Heteroplastic Bone Formation. Jour. Experimental Medicine, Dec., 1920, vol. xxxii, p. 745.

[7] Lichtwitz: Dtsch. med. Wochenschr., 1910, vol. xxxvi (1), p. 704.

THE OPERATION OF CHOICE IN THE SURGERY OF THE KIDNEY*

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In considering operations upon the kidneys there is one point of paramount importance which must be borne in mind and that is, that we are dealing with organs whose function is absolutely essential to life. The choice of operative procedure, therefore, cannot be governed by considerations which may govern the surgical treatment of other paired organs or of diseases of the gall-bladder, of the appendix or even of the genital organs. Whatever may be the final decision as to the function of the gall-bladder, for example, or as to the part played in the body economy by the secretions of the ovaries or the testicles, the fact remains that these organs can be dispensed with and that life can proceed with more than a fair efficiency. Fortunately there are two kidneys, and if one is permanently impaired or removed, the other can by certain compensatory changes take care of its increased load.

The essential character of the kidneys, therefore, makes the following the outstanding considerations which must be met in considering any surgical procedures upon them:

1. To establish definitely the presence or absence of a second kidney.

2. If one organ is impaired, to determine the functional capacity of the other.

3. If both organs are impaired, to determine whether or not the impairment of one is of a sufficiently minor degree to allow it to undertake the whole functional load.

4. If both are impaired, to determine whether or not the impairment of both is so slight, that first one and then the other may be repaired.

It should be borne in mind always that no operation upon the kidney should be considered a minor operation. Even pyelotomy for the removal of a stone, unless the stone lies with comparative freedom entirely within the pelvis, may be followed by the injury of the calyces and adjacent kidney tissue to such an extent as to diminish seriously the functional capacity of that kidney.

The outstanding conditions for which surgical procedures upon the kidneys may be demanded are tumors—which are almost always malignant; stones; infections—among which tuberculosis presents a particularly interesting problem; pyonephrosis; and hydronephrosis. In each of these conditions, except in the cases of those stones which, as is noted above, may be readily removed by means of a pyelotomy, a choice between a nephrotomy and a nephrectomy must be made. Before considering these various conditions in

* Read before the American Surgical Association, June 1, 1923.

detail, it is hardly necessary to emphasize the point that in every case the functional capacity of both the diseased and of the supposedly intact kidney must be rigidly determined. Some surgeons believe that if the kidney will function up to 35 per cent. of its normal capacity without liability of metastatic influence on other structures, it should be saved. Also it should be emphasized that in the determination of the identity of the suspected abnormality every diagnostic measure at our command—blood chemistry, dye excretion, röntgenograms, and urinographs—must be utilized.

The following comments regarding the operation of choice for the various pathological conditions included in this discussion are based upon my personal experience in 628 cases of surgical diseases of the kidney and 394 operations.

Tumors.—As I have noted above, tumors of the kidney are nearly always malignant. Even a papilloma which may appear frankly benign may be followed by a malignant recurrence. In the case of a tumor of the kidney, therefore, provided there is a second kidney and that kidney possesses good or fair functional capacity, nephrectomy should be performed, and if the tumor originated in the pelvis of the kidney the ureter on that side should be removed also.

In performing a nephrectomy for tumors of the kidney, as in all cases of malignancy, there should be as wide a resection of the tissue as possible, including the fatty capsule, and in most of the cases the operation should be followed by deep X-ray therapy. In some cases of sarcoma, it is remarkable how rapidly the tumor will diminish in size after the use of X-ray and radium, but I have never seen one of these cases cured in this way. Although in a large percentage of the cases there is a recurrence following operations, nevertheless there are a sufficiently large number of recoveries to warrant the opinion that surgical removal is the method of choice.

Stones.—The question as to what should be the procedure in cases of stone in the kidney or ureter has been under vigorous discussion for a long time. The cystoscope and ureteral catheter have made it possible to remove a fair per cent. of stones situated in the ureter by manipulation, but such attempts have been of little avail in the removal of stones in the kidney. Because a certain group of skilled manipulators have been fairly successful in removing stones from the ureter by means other than the open operation, advocacy of this method has led to an unwarranted effort on the part of many less skilled operators and much damage has been done with no corresponding benefit.

Having decided that an open operation is the method of choice in the removal of a stone in the kidney, what type of operation should be performed? Both clinical and experimental researches have shown that nephrolithotomy is attended by a higher mortality rate and a greater loss of function than pyelolithotomy. In only the exceptional case need the kidney be completely divided for the removal of a stone. A free opening of the kidney pelvis, extending the incision up into the cortical substance if necessary, as recently shown by Eisendrath, will permit the removal of a large branching stone with

little or no hemorrhage and a minimum destruction of kidney substance. In the occasional case it may be easier to remove an imbedded stone by a localized incision or puncture in the kidney, directly over the stone, but the bi-section of the kidney is a destructive operation which should be abandoned. The use of the fluoroscope as recommended by Braasch and Carman for the determination of the location of fragments or small stones is novel and has undoubted merit. When this cannot be done, the taking of a film with the kidney exposed as suggested by Quinby is another method of determining whether there are any remaining fragments. Irrigating the pelvis and calyces with syringe and catheter when the pelvis is opened will often remove small fragments which might be difficult to find by manipulation.

When stones are present in both kidneys the decision as to the method of intervention becomes more difficult. The location and not the relative size of the stones may be the determining factor as to which side should be operated upon first. A stone obstructing the ureter will more definitely impair the kidney function than will a large branching calculus which although it may fill the kidney pelvis and calyces, yet does not definitely obstruct the ureter. Cases of bilateral stones should practically always be operated upon, for although patients may live for many years with large stones in both kidneys, the stones will eventually destroy life if allowed to remain and a careful preparation and operation is not necessarily attended with a high mortality. The prevention of the recurrence of stones in the kidney presents a more difficult problem than their treatment.

Infections.—In cases of infection of the kidney it is not always easy to decide whether or not to operate. The presence of tubercle bacilli in the urine, especially if unilateral used to be and still is with many a sufficient criterion for operation. I do not believe so radical a stand should be taken. If there is a definitely localized tuberculosis on one side with abscess formation, there is no question as to the method of procedure and we all know the happy results obtained in these cases. But in those cases in which the only lesions found at operation are small tubercles, mostly beneath the capsule, with no definite walling off, operation often results only in a rapid lighting up of a general miliary tuberculosis and a speedy dissolution. The problem in such cases is, primarily, one of diagnosis, and I am convinced that if a correct diagnosis can be made by waiting, it is far better to wait than to operate upon some of these cases too early. I believe that we shall be able to work out a method whereby an accurate diagnosis can be made before operation is instituted.

If operation is decided upon, nephrectomy is, of course, the operation of choice. Even in cases of bilateral tuberculosis the removal of the more extensively involved organ will alleviate the symptoms. In cases of tuberculosis, however, operation is but one step in the course of treatment. The post-operative management of the case and the use of general hygienic measures play an important part in obtaining the best results.

In those cases of infection which are metastatic in origin, it is difficult

to decide what type of operation should be performed, if, indeed, one should operate at all. Personally, I do not operate on the so-called multiple septic infarct cases at once. Often these cases, even with very high temperatures and with involvement of both kidneys, will recover without surgical intervention. If well-defined localized abscesses develop, however, and the other kidney remains free, a nephrectomy should be performed.

Hydronephrosis presents a most interesting problem. Before Hinman performed his important researches in connection with this condition, we felt that it was sufficient to remove the cause of the ureteral obstruction whatever it might be in order to restore the function of the kidney. We now know, however, that in these cases the opposite kidney has hypertrophied and compensation has taken place. Removal of the obstruction does not restore to the kidney its functioning power so that instead of a working organ we still have, in many cases, only a large sac with little functioning substance. If infection is present, this shell is a definite menace to the other kidney, which is already doing the work of both. Therefore, instead of simply removing the cause of the obstruction, if it has existed for any length of time, the only safe procedure is to perform a nephrectomy.

It will be noted in the above discussion that we would appear to be favoring nephrectomy almost to the exclusion of nephrotomy and it is true that we are coming increasingly to adopt the point of view that provided one functioning kidney remains the dangers of nephrotomy are not justified. These dangers are briefly as follows: persistent hemorrhage; failure of the wound to close with the consequent leaving of a constantly infected urinary fistula; permanent damage to the kidney structure by contracting scar tissue; diminished resistance of the kidney operated upon; the increased danger of the recurrence of pathological conditions whether stone, infection or tumor; and finally the inevitable effect of a prolonged suppuration of one kidney upon its fellow.

Since the purpose of this paper is simply to present certain principles underlying the choice of operation, I have made no attempt to give detailed descriptions of the technic of the various operations.

CONCLUSIONS

No inclusive statement can be made regarding the operative management for any type of kidney lesion. All the factors in the individual case must be considered in making a decision as to the proper operative procedure. If the proper pre-operative precautions be taken and a careful choice of operation be made, the mortality rate of operations on the kidney will not be high. In my own series the mortality rate has been 1.7 per cent.

BIBLIOGRAPHY

Foster, G. S., and Miller, S.: The Surgical Kidney. A Systemic Method for Determining the Diagnosis and Nodus Operandi. International Clinics, vol. ii, p. 203, 1921.

Eisendrath, Daniel N.: Technic of Enlarged Pyelotomy for Renal Calculi. Surgery, Gyn. and Obs., vol. xxxvi, pp. 715–718, May, 1923.

Braasch and Carman: Renal Fluoroscopy at the Operating Table. Mayo Clinic, 1919, pp. 203–6.

CARCINOMA OF THE BLADDER*

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and

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This contribution to the study of carcinoma of the bladder is based upon the analysis of 131 cases occurring in our experience since 1910.

Of these 131 cases, 107, or 81 per cent., occurred in the male, and 24, or 19 per cent., in the female, a ratio of approximately four males to one female.

An analysis of the age at which these cases occurred, may be gleaned from the appended chart, showing that while carcinoma occurs at practically every age in adult life, it is most common in the fourth, fifth and sixth decades, during which periods 100 of our cases occurred. The average age in the total number of cases was 54.2 years. The statement has been made that carcinoma of the bladder is more commonly met with at an earlier age than carcinoma of other portions of the body. In our cases, however, the average age is about the same as carcinoma situated elsewhere.

Interrogation of the patients led to the discovery of a family history of carcinoma in 16, or 12.2 per cent. of the patients. Two patients with carcinoma of the bladder had previously been operated for carcinoma of the breast, and in one case the wife of the patient had been operated upon for carcinoma of the uterus.

Six of the 131 cases had had an operation for tumor of the bladder prior to coming under our observation. These cases are of special interest because of the long interval between operation and the date of recurrence. One case was operated upon twenty-one years before recurrence, one case nine years, one case six years, one case five years, and two cases four years; thus proving that no time limit of cure can be estimated in dealing with carcinoma of the bladder.

The diagnosis of carcinoma of the bladder was based upon: First: The microscopic examination of specimens removed by operation. Second: The microscopic examination of pieces of tumor removed by forceps or passed by the patient. Third: Cystoscopic examination. Microscopically, the evidences of malignancy vary within wide ranges, from the early degeneration of the epithelial covering of what might cystoscopically be judged benign papilloma, to the advanced carcinomatous papilloma, and finally the infiltrating squamous-cell carcinoma. This last type constitutes the most malignant carcinoma of the bladder, excepting the adenocarcinoma which has not been encountered among these cases examined microscopically. Correlating the clinical and microscopic findings, we have come to the conclusion that a truly benign tumor of the bladder is rarely encountered and that tumors of medium or large size, invariably show microscopic evidence of malignancy.

* Read before the American Surgical Association, May 31, 1923.

A review of the symptomatology of bladder tumor adds nothing of interest except to emphasize the lamented fact, recognized by every surgeon and urologist, that hæmaturia, the cardinal symptom of tumor, is disregarded as a symptom of serious import by the physician, and that procrastination takes the place of the cystoscope.

In only 21 cases was a cystoscopic examination made before three months of hæmaturia, and in 35 a period of from three months to one year had elapsed. In 48 cases a history of bleeding for over one year was elicited, and in 26 of these a history of hæmaturia for more than two years. It is indeed surprising how long a tumor of the bladder may exist and give rise to periodic bleeding and yet for many years have no apparent effect upon the general health of the patient. This would indicate that a large percentage of vesical neoplasms show a low degree of malignancy, and this, coupled with the fact that these tumors do not show a tendency to early metastasis, should place carcinoma of the bladder in a particularly favorable field for early curative surgery.

Pain is not a pronounced symptom of the tumor, and when it occurs it is usually late in the disease. Symptoms of cystitis, frequent, urgent urination with pus and blood in the urine is often a complication of carcinoma, in contrast with benign tumors which are rarely so complicated.

From a cystoscopic standpoint it is usually not difficult to make a diagnosis of tumor of the bladder since few pathologic conditions simulate it. Syphilis of the bladder gives rise to a nodular infiltration of the wall of the bladder, which may ulcerate and simulate carcinoma. It is impossible to differentiate the condition, and a positive Wassermann test should be followed by an active therapeutic test before surgery is advised. Some types of ulcerative cystitis, particularly a variety occurring in diabetes, of which we have seen two examples, resemble in appearance an ulcerative carcinoma. Fortunately, routine urine examination detects the presence of sugar, and under proper diabetic régime the cystitis subsides.

Tuberculosis of the bladder rarely simulates tumor, particularly when manifested in the form of tuberculoma.

While the diagnosis of neoplasm is usually easy, it is not always possible to differentiate the truly benign tumor from the early malignant one. Microscopic examination of pieces of apparently benign growths show epithelial changes of varying degrees, all indicative of malignancy, and these changes have so frequently been reported in cases of cystoscopically benign neoplasms, that we are led to believe that a truly benign tumor of the bladder is a rare occurrence. This is, furthermore, borne out from a clinical standpoint by the frequency of recurrences under any form of treatment, and by the fact that microscopic examination of these recurrent tumors, may show malignant changes undiscovered by the microscopic examinaton of the primary tumor.

Cystoscopically the characteristics of papillary carcinoma of the bladder are: Shortening or absence of the villous projection, evident ulceration of the tumor surface, an impression of density and an infiltration at the site of attach-

ment with a broad sessile base. In more advanced papillary carcinoma the bladder wall at the site of the tumor is infiltrated and œdematous while the remaining bladder mucosa is inflamed. Cystitis rarely accompanies a benign growth, so that the presence of a cystitis complicating a tumor is evidence of malignancy. Multiplicity of tumors is usually, but not always, indicative of malignancy, and large tumors likewise are practically always microscopically malignant. The cystoscopic diagnosis of infiltrating carcinoma of the squamous-cell type is based upon the presence of a tumor involving variable extents of the bladder wall, rarely exceeding a silver dollar in size, with a flat, rough ulcerated and bleeding surface, devoid of villous projection and fading off into the surrounding bladder wall, with no definite line of demarcation. It is frequently accompanied by marked cystitis. The size of a papillary carcinoma is limited only by the capacity of the bladder; squamous-cell and the more rare adenocarcinoma of the bladder infiltrate definite areas of the bladder wall, and commonly there is but one tumor present.

Various cystoscopic instruments and forceps have been devised to remove portions of a vesical tumor for treatment or for diagnostic purposes. The most satisfactory of these is the cystoscopic rongeur, with which a good sized portion of the tumor may be broken off and removed for examination. This was done in 23 of our cases in order to establish the diagnosis. Experience, however, with this method has led us to conclude that it is unnecessary and for the most part inadvisable. We have found that the removal of a portion of the tumor is not infrequently followed by considerable hemorrhage, and that retention of large clots in the bladder causes considerable trouble, necessitating their aspiration or an emergency suprapubic cystostomy. Furthermore in all cases where this procedure is used there is the possibility of opening up channels for the extension or the transportation of tumor cells. For these reasons we have practically discontinued the cystoscopic removal of portions of tumors for diagnostic purposes, preferring rather to rely upon the cystoscopic appearance of the growth in advising the method of treatment.

An analysis of our 131 cases shows that 10 cases received an opinion in which operation was advised, but as far as known the advice was not followed; 46 were declared to be inoperable because of the size and extent of the carcinoma and the general poor condition of the patient. Forty-two cases were operated upon by suprapubic cystotomy and the tumor dealt with in various ways, and 33 cases were treated primarily by endo-urethral fulguration.

In four of the 43 cases the bladder was opened and drained to meet the emergencies of retention of urine and excessive bleeding. No attempt was made to remove or destroy the tumor. One of these patients is alive; he has been wearing a permanent suprapubic drainage apparatus for a period of eighteen months and is able to pursue his usual occupation. Twenty-two cases were operated upon by excision of the tumor from the mucous membrane base, and in five of these the wound in the mucous membrane was repaired by catgut suture, while in 17 the base was cauterized with the

Paquelin cautery. In 7 cases the tumor was so situated as to allow a resection of the bladder wall with the attached tumor, without necessitating transplantation of either ureter.

Radium alone was implanted in one case, and in eight the tumor was thoroughly destroyed by the D'Arsonval current, followed by 1000 to 1500 milligram hours of radium applied in needles. In 33 cases the tumor was treated by endoscopic fulguration, using the Oudin current and supplemented in two cases by radium introduced per urethram.

It has been impossible, unfortunately, to trace the results of all the cases treated.

Of the 5 cases treated by excision of the mucous membrane and suture of the base with catgut suture, three have remained well and free from recurrences eighteen months, two years and two and a half years, respectively. One case had a severe post-operative hemorrhage twelve hours after excision, necessitating re-opening the bladder and using the cautery to control the hemorrhage. One case left the hospital presumably well, but never returned for observation. These cases were all of the papillary variety with definite and small pedicles easily removed by excision with subsequent suture of the denuded mucous membrane. This group is a very small one, but as far as is known, no recurrences followed and there was no mortality. In the 17 cases in which the tumor was excised and the base cauterized, 5 were examined six months, nine months (2), one year and four months after operation and found normal; 7 cases never returned for examination after discharge and 3 suffered recurrences, two in three months and one in four years. One case died in two months and one in one year, the tumor persisting after operation.

In the 7 cases of resection, three patients remained well, one, two and two and a half years respectively. One died in four months, and three have suffered recurrences, two in two years, and one in two years and three months. Cystoscopic fulguration has been applied in the treatment of these recurrences with varying degrees of success. In six cases, four have been successfully controlled over periods of from three to eleven years by examinations at intervals of from three to six months in each case; in two the recurrence failed to respond and operation being rejected, death ensued in seven months and three months, respectively.

Of eight cases treated by suprapubic cystostomy, high frequency destruction of the tumor with the D'Arsonval current and the implantation of radium, five were of the infiltrating type of carcinoma and three of the papillary type. Of the five cases of infiltrating carcinoma, one died in six days, and three within six months, all suffering complete invalidism from the date of operation to the time of death. One case of squamous-cell carcinoma has remained well three years. In three cases of papillary carcinoma so treated, one died in two weeks and two cases are reported well, one of them one year and seven months and the other two years and three months.

In one case in which radium was implanted without fulguration, death ensued in three months.

All 31 cases treated primarily by cystoscopic fulguration with the Oudin current were of the papillary carcinomatous type, many of them showing but slight epithelial evidence of malignancy; others, definitely malignant were advised to have a radical operation, but refused and were therefore treated in this manner. It is safe to say at the outset in discussing this group, that where definite cystoscopic evidence of malignancy exists, fulguration is usually not successful in the presence of an active cystitis, even when the treatment is facilitated in such cases by general anæsthesia. Occasionally one is surprised by an unexpected response to cystoscopic fulguration of a definitely malignant tumor; this, however, is exceptional. Of the 31 cases treated in this manner, four failed to respond to treatment and died in from six months to seventeen months; 13 were followed for periods of from three to ten years; in 3 of them recurrences were the cause of the return of symptoms after an interval of apparent cure of five, five and eight years, respectively. Of the 14 remaining cases, 4 were observed for one year, and 10 failed to report after intervals of three to nine months following an apparent cure.

A pathological examination was secured in 23 cases, using tissue which removed by cystoscopic forceps or rongeur, or occasionally passed by the patient, on which to base a diagnosis. It is from the study of these specimens that we have come to the conclusion that truly benign tumors of the bladder are rare. Two cases received intravesical applications of radium per urethram in addition to fulguration. No response to treatment was obtained in one case, death ensuing in eighteen months; the other has been an invalid for seven years but is probably cured of his cancer.

Summarizing the salient facts regarding carcinoma of the bladder as deduced from our experience, we are able to say that:

1. Carcinoma of the bladder occurs from three to four times more frequently in males than in females.

2. A family history of carcinoma was elicited in 12.2 per cent. of our cases.

3. Transient, symptomless hæmaturia is, as a rule, the first and frequently the only symptom of bladder tumor.

4. Such hæmaturia demands cystoscopic investigation; watchful waiting spells disaster.

5. A patient may live for a long time with a true carcinoma of the bladder, indicating a low degree of malignancy, and this, coupled with the recognized infrequency of metastasis, should place carcinoma of the bladder in a particularly favorable field.

6. Papillary carcinoma is ten times more frequent than infiltrating squamous-cell carcinoma.

7. Only in two-thirds of the carcinomas of the bladder encountered was any form of treatment justified. This is due to procrastination in diagnosis.

8. Practically all tumors of the bladder are malignant.

9. Cystoscopic fulguration is the best treatment of small or medium-sized single pedunculated carcinomas, uncomplicated with cystitis. It has little place in the treatment of semi-solid, sessile papillomas, and no place at all in the treatment of advanced papillary tumors or of infiltrating or squamous-cell carcinoma.

10. A choice of operative method in the treatment of carcinoma, here, as elsewhere, depends upon the situation of the tumor. Resection of the bladder with the tumor attached, where such can be accomplished without necessitating transplantation of the ureters, appears to us as the method of choice. Where resection cannot be done, excision with the cautery, or high-frequency destruction, is the next best procedure. The mortality of extensive resection with transplantation of one ureter, or total extirpation of the bladder with transplantation of both ureters, is extremely high, and is practically never justifiable. Radium has accomplished little in the cure of carcinoma of the bladder and has probably hastened a fatal termination in many cases in which it has been employed.

PATHOLOGICAL CHANGES, OCCURRING IN THE SPINAL CORD, FOLLOWING FRACTURE DISLOCATION OF THE VERTEBRÆ*

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In the following communication I shall try to describe simply and accurately the pathological changes, immediate and remote, that occur in the spinal cord when it is crushed by the displaced vertebræ in the condition known as fracture-dislocation.

Any consideration of direct wounds of the cord caused by penetrating bullets or shell fragments will be purposely omitted because these injuries stand in a class by themselves, in that they are compound fractures, and as such are liable to septic infection. Although infection is a rare complication in through-and-through bullet wounds, it often occurs in the ragged wounds produced by sharp pieces of shell, especially if the missile is retained in the spinal canal or carries in with it a piece of clothing. Apart from any consideration of the nervous injury, such wounds must be operated on to prevent death from septic infection, the object of the operation being solely the removal of the foreign body and the cleansing of the wound.

In crushes of the cord resulting from fracture-dislocation the nature of the injury is entirely different. There is no external wound and no danger of septic infection. Although the cord is often severely damaged by being pinched by the displaced vertebræ, the pressure is usually relieved by the recoil of the bones when the displacing force ceases to act. When the recoil is complete the damaged cord lies in the canal, which is not narrowed or distorted, but is as roomy as it was before the injury. On this account operation is seldom advisable or justifiable.

Fracture-dislocations of the spine may occur from direct or indirect violence. Those caused by *direct violence* may follow an injury acting in a horizontal plane such as a direct blow or kick or a sidewise impact caused by a fall. If the point of impact is concentrated on a spinous process it may fracture it or drive it inwards together with the laminæ against the cord, producing immediate symptoms of cord injury. If the spinous process and laminæ are strong and rigid the vertebra may be driven directly forwards and dislocated. As a rule the displaced vertebra retains its connection with the vertebra above, and the displacement forwards affects the whole of the upper part of the spine. The inter-vertebral disc between it and the body of

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the vertebra below is torn or portions of the bodies of both vertebræ are broken off obliquely. This may occur without fracture of the neural arch, or in the cervical region without even fracture of the articular processes, although the latter rarely escape injury. The cord is frequently crushed severely between the laminæ of the displaced vertebra and the body of the vertebra below.

Fracture-dislocations by *indirect violence* are caused by the application of a force at a distance from the lesion. Thus, a fall on the head will usually fracture the cervical spine, and a fall of a heavy weight on the nape of the neck will frequently fracture the thoracic vertebræ. Force acting downwards along the thoracic spine or upwards along the lumbar spine will frequently fracture the vertebræ at the thoraco-lumbar junction. The line of separation is usually through the intervertebral disc, but in addition the anterior surface of the bodies of the vertebræ may be chipped off obliquely and the articular and spinous processes broken irregularly. The vertebra above the lesion carrying the whole spine with it is displaced forwards and downwards on the vertebra below. If the displacement is great enough the spinal cord is crushed between the lamina of the vertebra above and the posterior upper edge of the vertebra below. As a rule the displacement persists as long as the force continues to act. As soon as the spine is straightened the deformity disappears because the vertebræ recoil to the normal position. In some cases, usually in the cervical region and particularly where the articular processes of the vertebræ are not fractured, *i.e.*, in cases which are, strictly speaking, examples of a dislocation, the recoil does not occur and the resulting deformity persists. In most of these cases reposition is possible by manipulation under an anæsthetic; but some cases resist all attempts at replacement.

It is of fundamental importance to emphasize the fact that vertebral recoil is the rule and that the moment the vertebræ return to their normal position, the vertebral canal is restored to its former size. The cord is no longer subjected to pressure, and from this time on if nervous symptoms persist other factors must be held responsible.

The exact nature of these factors will be revealed by a careful study of the pathological changes in the traumatized tissues.

The Vertebræ.—Sometimes the vertebral bodies escape injury completely, the line of separation passing accurately through the intervertebral discs. This is more frequently seen in the cervical region (Figs. 1, 2 and 3). In the thoracic and lumbar regions, although the main line of separation is along the intervertebral discs the anterior surface of the body of the vertebra below the line of separation is usually chipped off obliquely. Occasionally the chipping affects the bodies of several vertebræ, including the body of the vertebræ above the line of separation. Sometimes a considerable wedge of bone is

chipped off; at others the fragments of bone are of small size. It is caused partly by the direct impact of the displaced vertebra above and partly by the pull of the anterior common ligament which is torn up bodily from the front of the bodies of several vertebræ below the line of separation. In cases that die shortly after injury extensive extravasation of blood can be seen, at autopsy, in this situation. In rare instances the bodies of the vertebræ are fissured transversely (Fig. 8). The articular processes rarely escape injury. In the cervical region, if anterior flexion of the upper vertebræ is extreme at the time of the accident, the ligamenta subflava and interspinous ligaments may be torn and the articular processes of the displaced vertebra may be carried forwards in front of the lower without breaking either one (dislocation). Usually, however, one or both articular processes are fractured. In the thoracic and lumbar regions fracture of the articular processes is the rule. In rare instances, however, when flexion of the spine is excessive they may ride over one another without breaking. In addition the displacement frequently tears up one or more spinous processes. The laminæ and pedicles are rarely broken in fracture-dislocations caused by indirect violence. Where the violence is direct both laminæ and pedicles are frequently fractured.

The Spinal Canal.—In cases where the recoil is complete the spinal canal is not narrowed or encroached upon in any way. Narrowing of the canal is seen only in cases of pure dislocation or fracture-dislocation where reduction is incomplete, and in cases of fracture of the laminæ from direct violence where the bone has been driven inwards.

Extravasation of Blood in the Spinal Canal.—Even in cases operated on, or autopsied early or within the first week, the quantity of blood found between the bone and dura mater is very small. We have never seen an extravasation large enough to cause pressure on the cord or even to cause the dura mater to bulge towards the cord. These observations are in complete accord with those of Thorburn and others. Occasionally we have found small worm-like extravasations situated several vertebræ below the crush.

The Dura Mater.—Tears of the dura mater are rarely seen except in direct wounds. Those seen in museum specimens are usually made during the removal of the cord. During operations on recent cases in which complete recoil of the vertebræ has occurred, there is ample space between the bone and dura. In old standing cases, the dura is often very adherent to the ligamenta subflava and the laminæ of the vertebra, especially when marked deformity exists. Adhesions are also frequently seen between the dura and pia in old cases where deformity persists and the cord is crushed completely (Fig. 22).

The Arachnoid.—As in the normal state the arachnoid is closely applied to the inner surface of the dura mater. In recent cases the subarachnoid space is not narrowed. There is free circulation of subarachnoid fluid across the site

of the crush. The fluid is often blood-stained, but it is rare to find it so thickly mixed with blood as we see it in some fractures of the base of the skull. Clots are rarely seen. When present they are very small and are found clinging to the surface of the crushed pia mater. We have never seen a clot large enough to produce pressure on the cord or even to fill the subarachnoid space. In old standing cases the arachnoid may adhere to the surface of the pia and interrupt completely the subarachnoid space above and below the adhesions. (Case XIII, Fig. 22.)

Pia Mater.—Except in direct wounds the pia mater is seldom torn. Although it is a thin membrane, it is very tenacious. Even in examples of complete pulping and crushing of the cord, the disintegrated nervous matter will be forced upwards and downwards along the intact pia mater, which rests in the dural sheath like a tube or sleeve of fine gauze stretching between the proximal and distal ends of the cord. In cases where the vertebral deformity persists the disintegrated nervous matter is prevented from returning into the tube of pia. Consequently at operation or autopsy a thin flattened tape-like tube of pia is seen holding together the severed ends of the cord. This condition is shown in Figs. 18 and 23. Extravasations of blood between the pia mater and the cord are usually minute in size. Most of them are the superficial outcrops of the larger foci extravasated in the depths of the cord.

Spinal Cord.—It is vitally important to visualize the structural changes that occur in the architecture of the cord and to estimate them at their true value. The primary effect of injury, whether it be a direct crush or a molecular vibration produced by a penetrating missile or by a contusion, is to destroy the ganglion cells, axis cylinders and myelin sheaths by shaking them loose from their supporting network of glial tissue, reducing them frequently to a hopeless pulp of disintegrated material, in which it is impossible to recognize the essential nervous elements, or in fact to distinguish any structure except the lacework of the neuroglia. There is of course extravasation of blood because such destructive processes cannot occur without tearing blood-vessels. The extravasations, however, are small and are confined, as a rule, to the injured zone. There is no tendency for the blood to travel into areas which have escaped injury. In recent cases the extent of the area of nervous destruction is often graphically indicated by discoloration from extravasated blood which occupies the interstices of the glial network from which the nervous elements have been squeezed by the crush. This is shown, not only in human cords removed at autopsy, but in the cords of dogs traumatized experimentally. The area and shape of the disintegrated area is very uniform when the nature of the force producing it is also uniform and focussed. Conversely it may be just as irregular when the force is applied irregularly and diffused. Thus, in crushes of the cord produced by displaced vertebræ or those produced experi-

mentally by carefully applied and graduated force the injured areas are surprisingly alike; whereas in those produced by missiles or contusions they are subject to many variations in size and shape. The crushed area is often indicated by the presence of extravasated blood which can be seen through the pia mater if it is near the surface of the cord. In many cases where the whole thickness of the cord has been crushed for an appreciable distance, a dark band or ring of extravasated blood may indicate the injured area. This is frequently seen in the cords of dogs crushed by the pulp of the experimenter's finger. Such cords often show an area of discoloration extending upwards and downwards from the bruised level, which represent the areas of destruction. These areas are cone-shaped, united at their bases, which correspond to the line of crush, and tapering upwards and downwards in the substance of the cord. Thorborn and Richardson, who first described this peculiarity, found that the lower cone was more truncated than the upper. This appearance is so constant that it suggests strongly that the mechanism of destruction is a vibratory wave which starts at the point of impact and exerts a divulsive action on the friable nervous tissue. It can be imitated very closely by crushing transversely a ripe banana in its skin with the edge of a ruler or a lead pencil. A horizontal section will show cones of bruised pulp, exactly like those seen in the spinal cord which stand out in striking contrast with the sound pulp if the fruit is kept for twelve hours.

As a rule the disintegrated area can be distinguished by its blood-stained appearance. It is probable that some degree of extravasation always accompanies disintegration. It must, however, be emphasized that massive hemorrhage and clots never occur even at the area of greatest destruction. It has appeared to us that the disintegration is more marked at the point of impact and that the cone-shaped areas of destruction occupy the centre of the cord without any particular preference for either gray or white matter. This feature will be considered later in the description of actual specimens. Apart from discoloration at the point of impact the appearance and shape of the cord may show no change. Even where its substance is completely crushed, the disintegrated material may flow back into the uninjured sleeve of pia mater and fill it up completely so that it looks as symmetrical as it did before the injury. If, however, pressure is kept up for a long period, the cord will remain narrowed permanently. We shall picture such cords later.

The foregoing remarks are founded mainly on a study of the spinal cords preserved in the pathological museum of the University of Texas. We shall now proceed to describe their pathological features. For convenience we have divided them arbitrarily into four groups. In the first group we have placed the cases of instantaneous death caused by a crush above the origin of the phrenic nerve. The second group contains the cases living a few days only; the third, a few weeks, and the fourth, a longer period.

GROUP I, CASES OF INSTANTANEOUS DEATH

CASE I.—McG. Sealy Hospital. Autopsy No. 524. The patient, age forty-two years, fell down an elevator shaft and was picked up dead. Abnormal mobility with crepitus was found in the lower cervical region.

The autopsy revealed a fracture-dislocation at the level of the intervertebral disc between the 5th and 6th cervical vertebræ. The 5th vertebra carrying the upper vertebræ with it had been displaced forwards on the 6th. The recoil, shown in Fig. 1, was practically complete and very little deformity

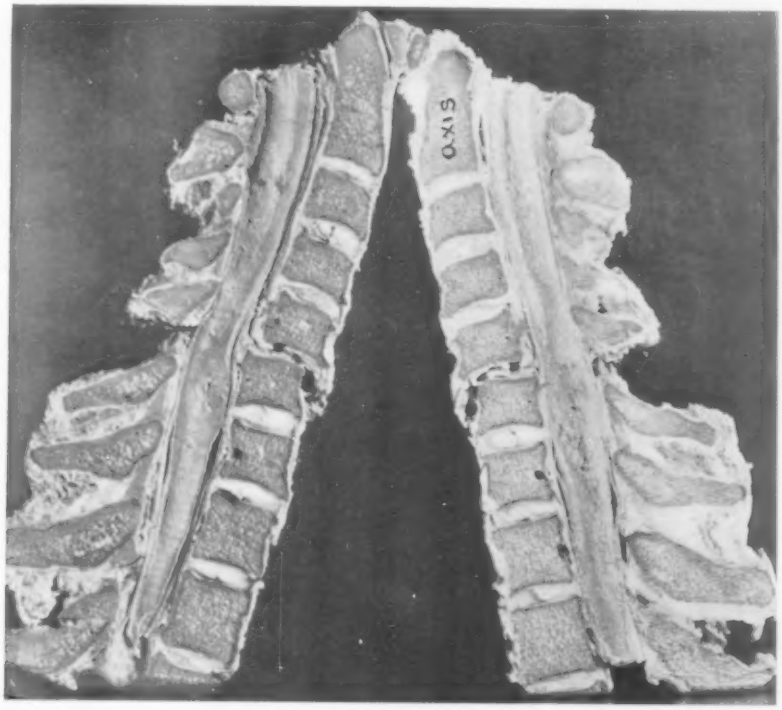

FIG. 1.—Case 1. Photograph after recoil.

was present. The interspinous ligament between the 5th and 6th spines was completely torn. Evidently the spinal column had been bent acutely forwards and the 5th vertebra displaced forwards to a considerable distance crushing the cord severely. Extensive pulping of the cord tissue can be seen. It is shown by longitudinal streaks of disintegrated tissue which extend upwards as high as the middle of the 3rd cervical vertebra and as low as the upper border of the 7th. The lower area shows cavitation. There is no sign of hemorrhage either in the membrane or in the substance of the cord. Death was practically instantaneous because the crush was above the origin of the upper roots of the phrenic nerves.

A longitudinal section of the fractured spine is shown in Fig. 1. In Fig. 2 the deformity has been reproduced to show the mechanism of the fracture and the kind and degree of deformity.

No microscopic sections were made of the specimen, because it had been frozen and divided with a saw before being mounted, and we were afraid that

the nervous structures would be seriously injured and distorted by the mechanical injury.

CASE II.—J. B. Sealy Hospital. Autopsy No. 501. The patient fell down an elevator shaft and was picked up dead. There was abnormal mobility of the upper part of the neck with crepitus.

The autopsy revealed a fracture-dislocation of the cervical spine which showed some unusual features. The line of separation between the bodies of the vertebræ passed between the 2nd and 3rd cervical. The intervertebral disc was ripped up completely from its bed. It was held in contact with the displaced body of the 2nd by the anterior common ligament. Both pedicles of the arch of the axis (2nd) were broken. The interspinous ligament between the atlas and axis was torn through completely and the separation between the posterior arches of these vertebræ was so great that the dura mater could be felt by the finger. The line of separation between the vertebræ was therefore very irregular and oblique, to wit: between the bodies of the 2nd and 3rd, through the pedicles of the 2nd and between the arches of the 1st and 2nd.

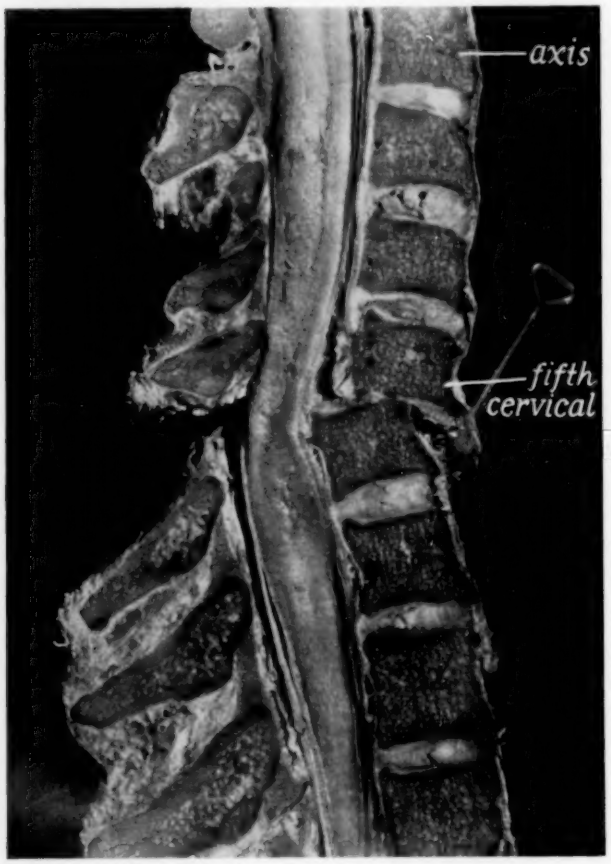

FIG. 2.—Case 1. Deformity reproduced.

There was no hemorrhage to speak of in the soft tissues of the neck; and none at all in the extradural space. The intradural space was free from hemorrhage. The cord showed no signs of bruising. It did not appear to be compressed, nor were there any hemorrhages in its substance. A slight angular bend is shown in Fig. 3. The absence of hemorrhage is probably due to the instantaneous death. In this respect it is analogous to Case I. On account of the method of preparing the specimen, namely, freezing and sawing, no microscopic sections were made.

Remarks.—In both cases there are two conditions worth emphasizing, (1) the absence of hemorrhage either in the cord or the structures around it;

and (2) the complete recoil of the vertebræ with restoration of the spinal canal and release of the pressure on the cord. Instantaneous death accompanied by immediate arrest of the heart's action would explain the former.

GROUP II, CASES DYING A FEW DAYS AFTER THE INJURY

CASE III.—L. P. C. Hospital No. 131212. Autopsy No. 1627. The patient was admitted to the Sealy Hospital on October 16, 1922, showing symptoms of a total transverse lesion of the spinal cord associated with a fracture-dislocation

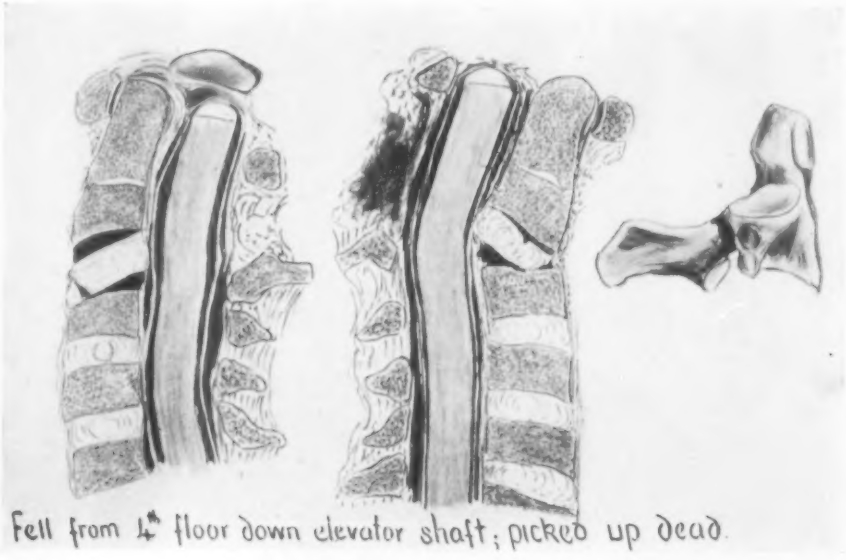

FIG. 3.—Case 2. Drawing in the centre shows the deformity; that on the left the appearance after recoil.

of the spine, which had resulted from a direct crush between an elevator and the floor. He was suffering from severe shock, and consequently the examination of the motor and sensory functions was very unsatisfactory. The ulnar border of the forearm and ulnar half of the hand were insensitive, and flexion of the wrist impossible. There appeared to be complete anæsthesia and flaccid paralysis below the level of the 7th cervical segment. The patient remained in a condition of profound shock until his death, which occurred twenty-four hours after the injury.

At the autopsy a fracture-dislocation was found (Fig. 4), the line of separation passing between the bodies of the 7th cervical and 1st thoracic vertebræ. There was very little original deformity and the spinal canal was not much narrowed. A large extravasation of blood was found in front of the bodies of the vertebræ, under the anterior common ligament. It extended downwards as far as the mid-dorsal region. There was no blood in either extradural or intradural space in the neighborhood of the lesion. A very small worm-like clot was found clinging to the outer surface of the pia mater about three inches below the lesion. The cord at the level of the lesion was slightly flattened, but not disintegrated. Several small hemorrhages were seen on its outer surface. Both dura and pia mater were intact.

A section of the cord taken through the lesion is shown in Fig. 5. The cord is flattened in front, and both white and gray matter are distorted. Numerous hemorrhagic foci are seen scattered throughout the section in both white and gray matter. The gray commissure is completely hemorrhagic. A noticeable feature is the complete absence of the changes usually associated with œdema. The cord is not swollen. On the contrary it is smaller than normal, and the pia mater is wrinkled. In spite of the flattened distorted shape of the cord the sheath of pia mater is intact everywhere. The wrinkling shows best on its posterior surface. Identical findings are shown in the dog's cord pictured in Fig. 28.

FIG. 4.—Case 3. Slight angular deformity; absence of hemorrhage in meninges: hemorrhage without marked crushing of the cord.

The microscopic findings do not reveal enough destruction to justify a conclusion that the conductivity of the cord was destroyed completely and permanently. It is probable that, if the patient had lived long enough, both motion and sensation would have been restored to a considerable degree.

At the autopsy, a gangrenous appendix was found. It had not perforated. The patient was feeling very sick when he started work on the morning of the accident, and the mishap was caused probably by his lack of alertness.

CASE IV.—R. B. Hospital No. 8799. Autopsy No. 1650. The patient was admitted to the Sealy Hospital on January 29, 1923, deeply intoxicated with alcohol. There was a history of a fall of about 15 feet. We were unable to get accurate information as to when the accident occurred. It is probable, however, that he was hurt on the night of January 28th, the day before his admission. He died at noon on January 30th. He probably lived about 40 hours after the injury. The interne who examined his chest on the afternoon of his admission said that he was able to hold his body in a sitting posture during the examination. This statement is probably not reliable because the patient was comatose from alcohol and was supported by an orderly.

Fractured spine was suspected during the visit of the attending physician on the morning of January 30th. The patient was semi-conscious and the examination

was unsatisfactory. There was flaccid paralysis of both lower extremities and complete anæsthesia. All the deep reflexes were absent. He was unable to move his arms. Sensation in the arms and forearms was indeterminate. He was not conscious enough to justify any conclusions. Examination of the muscle reflexes was very definite. There was well marked response in the biceps, triceps

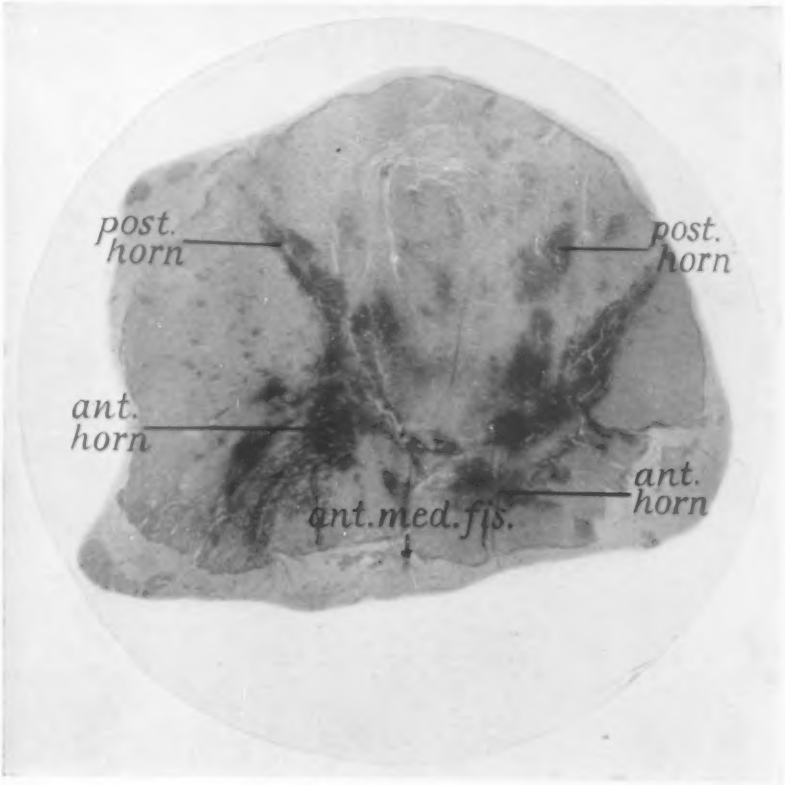

FIG. 5.—Case 3. Photomicrograph of site of lesion showing hemorrhage and slight flattening.

and extensors of the forearms. From this we thought the spinal lesion had not destroyed the 7th cervical segment completely. The superficial reflexes of the abdominal wall were also present. Spinal puncture showed uniformly bloody fluid.

The autopsy showed a fracture-dislocation between the 5th and 6th cervical vertebræ with slight displacement of the 5th on the 6th. Unfortunately the crushed segment of the cord was seriously damaged during its extraction, because as soon as the dura mater was opened the softened cord oozed out. A photograph of the gross specimen is shown in Fig. 6. The level of the lesion was crushed to a shapeless pulp permeated throughout with extravasated blood. No microscopic section was made here because it seemed to be completely disorganized. The gross appearances of the cord about 1 cm. above and below the lesion are shown in the picture. In that taken from above there is widespread extravasation of blood in the gray matter of both anterior cornua and in the deep part of the posterior columns abutting on the posterior commissure. In that taken from below, the cord is flattened obliquely and the extravasation is confined mainly to the centre of the section. From the upper end of this section, through

the part nearest the pulped area, the specimen shown in Fig. 7 was prepared. It shows such distortion of the cord that orientation was rather difficult. The anterior and posterior horns of one side and practically all the posterior columns of both sides are pulped. The crushed area is permeated with extravasated blood and completely shattered.

Case V.—H. W. Sealy Hospital, Gen. No. 116594. Autopsy No. 1289. The patient was admitted to the Sealy Hospital on January 21, 1919, suffering from symptoms of a complete transverse lesion of the spinal cord at the level of the 7th cervical segment of the cord, caused by a fall on the back of his head. When first admitted he could distinguish pin prick over several irregular areas in both legs. Later on there was complete flaccid paralysis with absent reflexes and complete anæsthesia to all types of stimuli below the lesion. He could move the arms and forearms sluggishly. He could flex the fingers of both hands slightly, but could not extend them. There was complete loss of control of bladder and rectum.

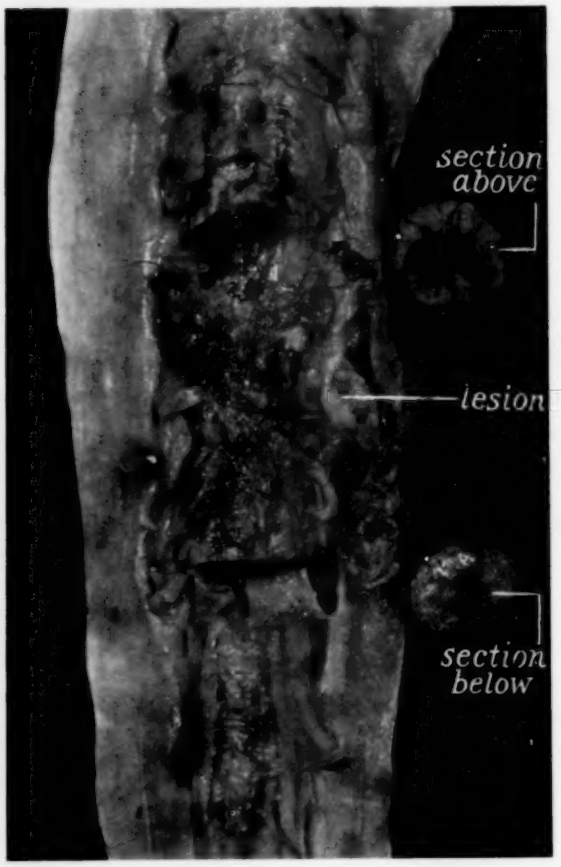

Fig. 6.—Case 4. Extensive destruction; with pulped cord flowing through tear in pia.

The X-ray showed that the body of the 6th cervical vertebra was broken and that it was separated slightly from both the 5th and 7th.

The patient failed rapidly. Breathing became labored, and before death Cheyne-Stokes' respiration set in. He died on January 27th, *i.e., 6 days after the accident.*

The autopsy showed softening and separation of the intervertebral discs between the 5th and 6th and between the 6th and 7th cervical vertebræ. The body of the 6th was fractured transversely (Fig. 8) and the right transverse process was broken off. There was a very small hemorrhage between the dura mater and bone at the level of the body of the 6th thoracic, but none inside the dura mater. The spinal cord at the same level was soft, flattened and dark colored from hemorrhagic extravasation in its substance. Unfortunately the whole cord was not preserved. Three blocks of the cord, taken respectively through the lesion, above it and below it were kept permanently. The appearance of these sections is shown somewhat diagrammatically in Fig. 8.

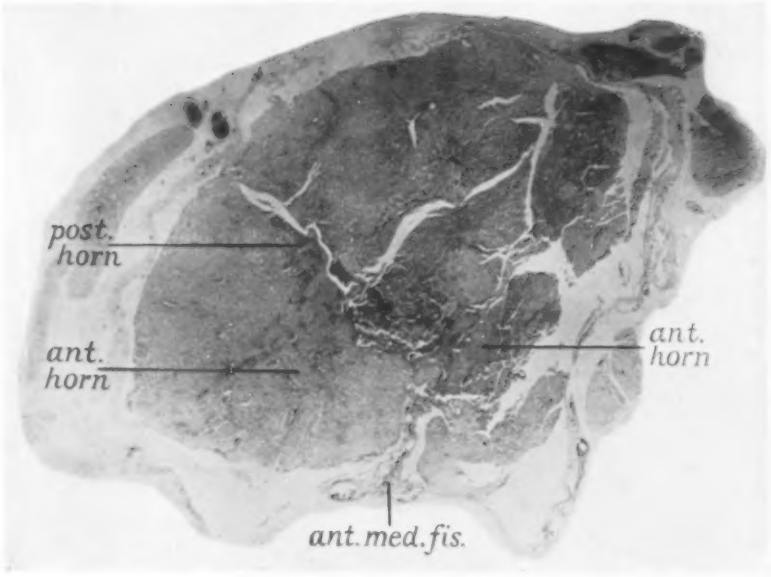

FIG. 7.—Case 4. Photomicrograph of cord 1 cm. below crush.

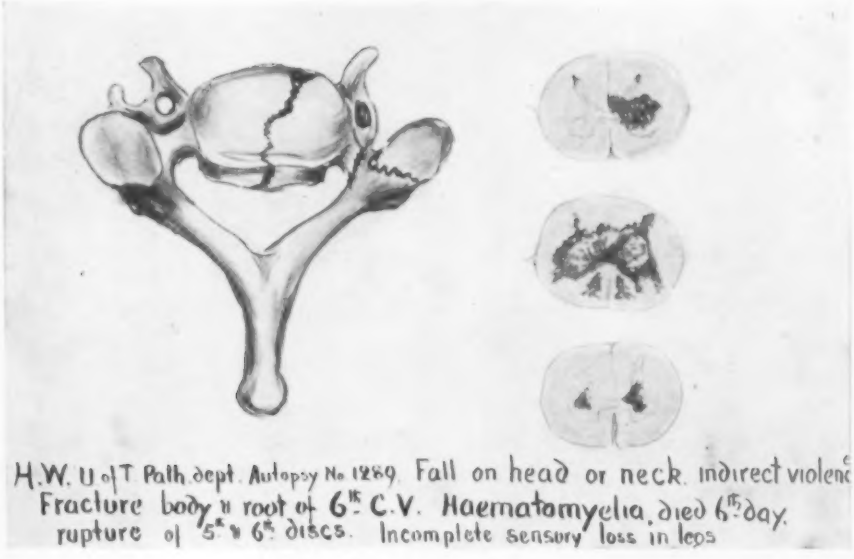

FIG. 8.—Case 5. At the right are shown the hemorrhages above, through and below the lesion.

At the level of the lesion the cord was seriously crushed and there was considerable extravasation of blood throughout the gray matter. There were also two wedge-shaped symmetrical extravasations on either side of the anterior median fissure. The section taken 2 cm. below the lesion showed two small symmetrical extravasations in each anterior cornu. In the section taken about a vertebral segment above the lesion the hemorrhage was confined mainly to one anterior horn. The microscopic appearances are shown in Fig. 9. The areas of hemorrhage are shown at h. h. Vacuolation is present at the periphery, a. a. Œdema is present everywhere. It is especially intense in the neighborhood of the

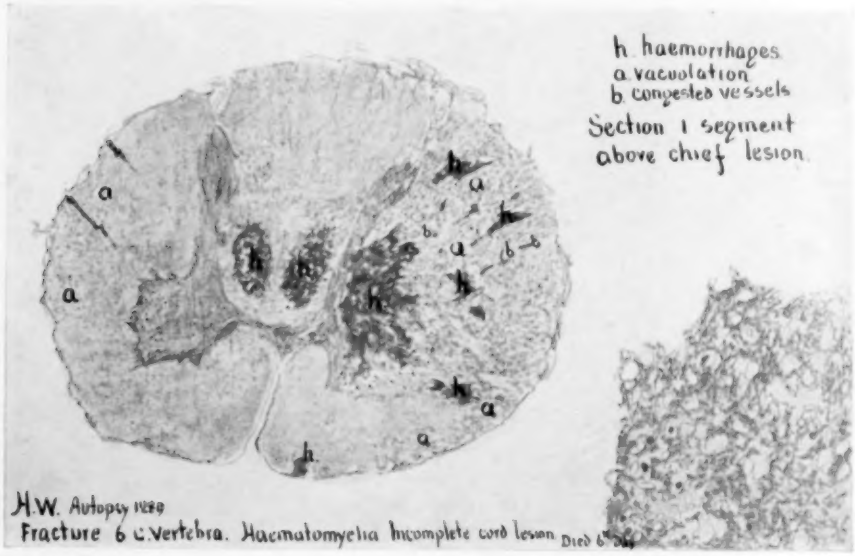

FIG. 9.—Case 5. Drawing of microscopic section above lesion.

hemorrhagic zones. The changes here seem to suggest that the open network appearance of the tissues surrounded by blood extravasation may represent the early stage of liquefaction of the disintegrated tissues which may finally terminate in the formation of vacuoles or actual cavities like those occurring in syringomyelia.

Remarks.—The three cases lived respectively 24 hours, 40 hours and 6 days. In all of them we found extravasation of blood scattered alike in gray and white matter. It was the outstanding feature. The degree of destruction at the level of the lesion varied greatly. In Case III the anterior part of the cord was compressed and distorted. In Case IV one-half the cord was pulped and destroyed. In Case V, the cord was crushed and flattened, but not completely destroyed. There was no œdema in either Case III or IV, but in Case V œdematous changes were seen in every section. In the cord above the lesion they were especially intense. It would appear from the absence of œdema in Cases III and IV, who survived, respectively, 24 and 40 hours, that it does not make its appearance so soon after the injury as some observers claim. There is no difficulty in recognizing it when present. The tissue assumes an open network appearance that is absolutely characteristic. It has

appeared to us that some of the œdematous areas situated in the middle of dense extravasations of blood were in the early stages of liquefaction. In most of the sections we found œdema more marked at the periphery and especially in the lateral and posterior columns. In these situations it appears to represent the early stages of tract degeneration.

GROUP III, PATIENTS LIVING FROM TWO WEEKS TO A MONTH

CASE VI.—A. S. Hospital No. 103,459. Autopsy No. 915. Admitted to the John Sealy Hospital on September 24, 1915, suffering from complete paralysis

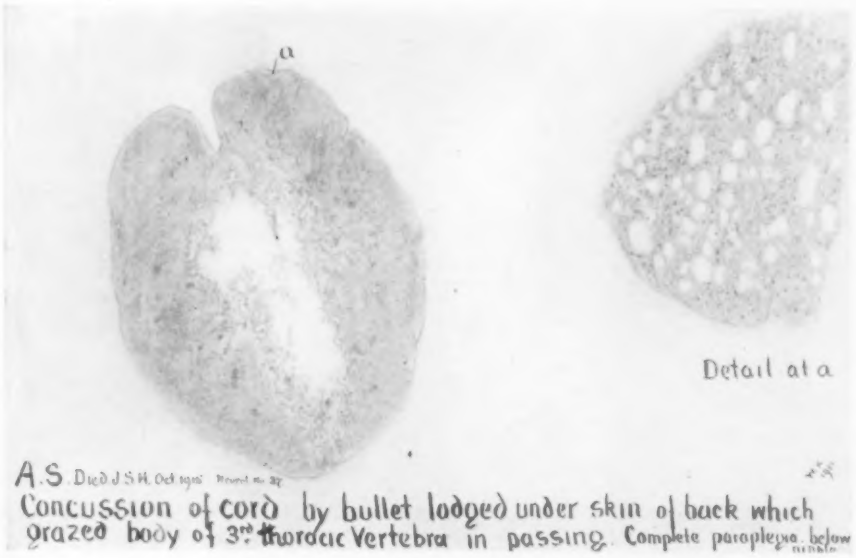

FIG. 10.—Case 6. Drawing of microscopic section through lesion.

and anæsthesia of the body below the level of the second thoracic segment caused by a bullet which had passed across the upper part of both left and right pleural cavities. The signs were those of a complete transverse lesion, *viz.*, absolute flaccid paralysis, total absence of every kind of sensation below the lesion and loss of control of bladder and rectum. Both deep and superficial reflexes were absent and never returned. The patient died on October 7th, *i. e.*, 13 days after the injury.

The autopsy showed a wound of the right lung, fracture of the 3rd left rib and a perforation of the body of the 3rd thoracic vertebra. In addition there was purulent cystitis and acute diffuse nephrititis. The spinal cord was removed and the spinal canal carefully examined. There was no direct wound of the cord. The track of the bullet was shown by a slight elevation of the bony wall of the spinal canal in front. The dura mater was slightly torn. The cord and pia mater were untouched. There was a small extravasation of blood in the extradural space, but none in the subdural. The cord was slightly blood-stained and softened. It did not appear to be completely crushed.

A section of the cord through the lesion is shown in Fig. 10. The area of greatest destruction is in the gray matter and the posterior columns. Extensive cavitation is present in this area. Œdematous changes are present in every part of

the undestroyed cord. The detailed appearance of the œdema and vacuolation is shown in the insert at *a*. A section of the cord taken 2 cm. above the lesion (Fig. 11) shows two principal areas of destruction, one in the gray matter of one posterior horn and the other in the lateral column of the same side. The position of the posterior horn is occupied by a pyriform-shaped cavity. On the lateral wall of this cavity some of the nerve fibrils of the posterior horn can be seen. The cavity in the lateral column occupies the position of the spinothalamic tract. Its

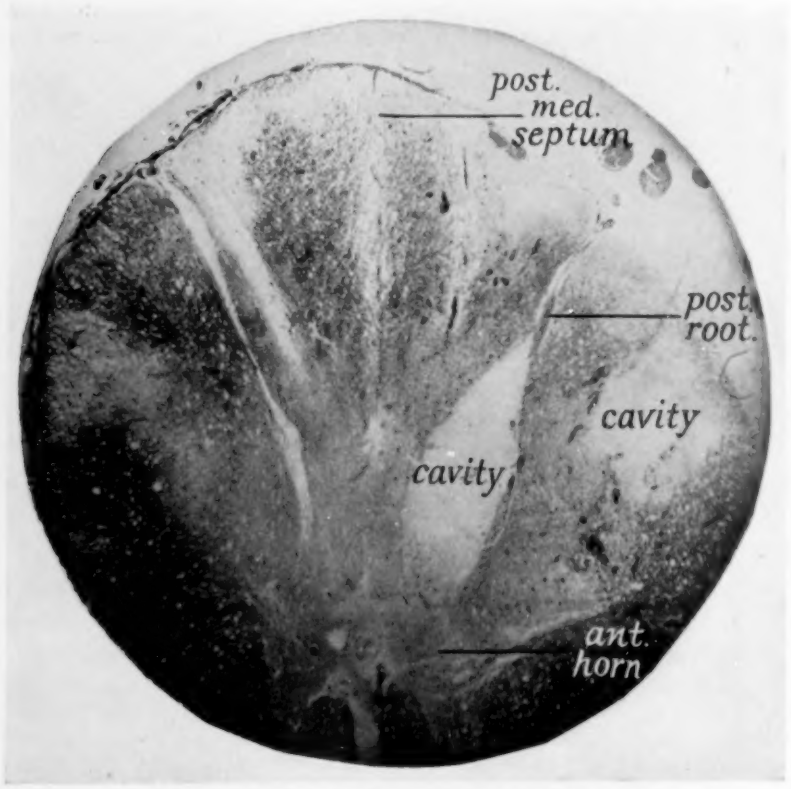

FIG. 11.—Case 6. Photomicrograph 2 cm. above the lesion showing œdema and cavitation.

walls are formed by disintegrated tissue and are poorly defined. In a similar position in the opposite lateral column there is an area of degeneration. Œdema is well marked throughout the section.

Remarks.—The area of destruction was much greater than we expected to find from the naked eye characters of the cord. Although the greater part of the lateral columns seem to have escaped disintegration, they are seriously shattered. The gray matter was completely destroyed for the distance of one spinal segment at the least. It is interesting to note that cavitation was also present in the section taken 2 cm. above the lesion. It is more than probable that the lesion was anatomically a complete transverse one. The case is particularly interesting because there was no direct wound or crush of the cord. The

lesion was caused by vibratory impulses transmitted by the bullet during its passage through the body of the vertebra. Such cases are examples of pure concussion.

CASE VII.—W. L. U.S.P.H. No. 905. Autopsy No. 1415. Admitted into the John Sealy Hospital, September 9, 1920, suffering from complete paralysis and anæsthesia below the level of the 10th thoracic nerve, which had resulted from a fall of 30 feet into the hold of a ship. The back and legs were bruised. The symptoms were those of a complete transverse lesion, *viz.*, complete flaccid paralysis, complete anæsthesia to every form of stimulus, absence of complete

FIG. 12 A.—Case 7. Extensive pulping from concussion.

reflexes and complete loss of control of the bladder and rectum. The X-ray report pointed to a dislocation of the 10th thoracic vertebra. On September 11th (*i.e.*, two days after admission) laminectomy was performed by another surgeon. The laminæ of the 10th, 11th and 12th thoracic vertebræ inclusive, were removed. Neither fracture nor dislocation was found. The fat and muscle over the vertebræ was infiltrated with blood. No blood was found in the spinal canal. No lesion of the cord was seen. The patient died on October 5th (*i.e.*, 26 days after injury), the cause of death being probably renal sepsis. During this period there was no amelioration of the symptoms. Reflexes never returned.

The autopsy was limited to an examination of the brain and spinal cord, which was done very carefully by Drs. W. Keiller and H. O. Knight. There was no evidence whatsoever of any fracture or dislocation of the vertebræ or any distortion of the spinal canal. The operation had failed to expose the site of the lesion of the cord which was at the level of the ninth thoracic segment. At this spot the cord was softened and diffluent. Above and below the lesion there were cavities filled with blood and disintegrated nervous matter. There was no hemorrhage either extra- or intradural. The microscopic appearance of

the injured segment is shown in Fig. 12, A and B. The normal tracts and areas are almost unrecognizable. Nothing except a nebulous mass of disintegrated tissue can be seen.

Remarks.—The case is a striking example of the effects of vibratory impulses on the cord. The absence of fracture or dislocation was proved beyond the shadow of a doubt by a painstaking examination conducted by two experts with the express purpose of finding out whether concussion was responsible for the symptoms or whether a fracture-dislocation had been overlooked at the operation. At the autopsy there was effusion of blood in the

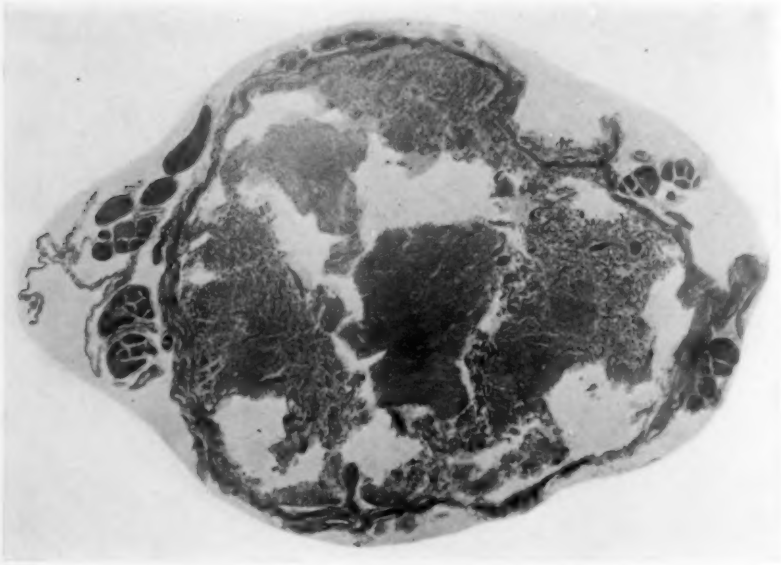

FIG. 12 B.—Case 7. Photomicrograph of Fig. 12 A.

spinal muscles over the greater part of the dorsal region. The mechanism of the fracture was probably a direct blow, probably horizontal in direction, caused by the impact of the back against the combing of the lower deck. Such complete destruction is unusual. The vibratory impulses must have been excessive and concentrated. No hope of recovery was possible because all conducting paths were destroyed totally.

CASE VIII.—F. L. Sealy Hospital, No. 120527. Surg. Path. No. 1365. The patient, a male, aged thirty-two, received a direct blow on the lower cervical spinous process from the handle of a hand car on July 7, 1920. The symptoms of a complete transverse lesion at the level of the 6th cervical segment were noticed at once. He was brought from Mexico to Galveston and arrived ten days after the injury. He was completely paralyzed and anæsthetic below the level of the 5th segment. All reflexes were absent. There were bed sores on the buttocks and heels. There was retention of urine and all the signs

of septic cystitis. X-ray examination showed considerable forward displacement of the 6th cervical vertebra on the 7th.

He was very septic on admission, but later on the fever disappeared. Two days before his death respirations became very slow, from 6 to 8 per minute. He died of respiratory failure 20 days after the injury.

The autopsy was made after careful embalming. The 6th vertebra was found displaced forwards on the 7th so far that the spinal canal was occluded and the cord completely crushed, Fig. 13. The right upper articular process of the 7th vertebra was fractured. There was no meningeal hemorrhage. At the level of the lesion the cord was completely pulped and squeezed out of the sheath of a pia mater for at least 0.5 cm. The pulping of the cord extends upwards and downwards for at least a spinal segment in each direction, *i.e.*, it includes the 5th and 7th spinal segments. On section of the cord above and below the lesion a central degeneration and hæmatomyelia extended upwards as far as the 4th segment, and downwards as far as the 1st thoracic segment. There was no adhesion of the dura mater and arachnoid to pia, and the subdural space above the lesion communicated freely with that below.

The appearance of the injured cord is shown in Figs. 13, 14, 15 and 16. At the site of the crush all trace of nervous tissue had been squeezed out of the pial sheath. A section at this level showed nothing but pia mater and nerve roots. A section taken 3 cm. above the crush (Fig. 14) showed a large cavity situated in the posterior column of white matter. It occupies the central part of the columns of Goll and Burdach on one side and abuts on the posterior cornu and the gray commissure. In the section taken 2 cm. below the lesion (Fig. 15) a smaller cavity was seen occupying approximately the same posture. Numerous small extravasations of blood are present in the gray matter and in the white matter of the lateral columns. At the periphery of the section, especially in the region of the lateral columns, there are marked evidences of œdema. The section taken 2 cm. below the lesion shows similar changes. The cavity is much smaller and seems to be divided into two parts by a septum of disintegrated tissue. There is a localized œdema at the periphery of the lateral columns. (See Case XII, Fig. 26.)

Remarks.—The great interest in this case lies in the cavitation of the interior of the cord. In discussing the mechanism of crushes of the cord mention was made of an area of disintegration which extends from the part crushed upwards and downwards. This is shaped like two truncated cones, the bases of which face one another at the site of the lesion, while the apices point upwards and downwards.

Soon after the injury the cone-shaped pulped area presents a characteristic appearance. It is traversed in every direction by fissures which split it up into irregular masses which separate it from the uninjured cord which surrounds it. Diffuse extravasation of blood is present in every part of the pulped area. Later on the whole area has a tendency to undergo liquefaction, which may be followed either by absorption resulting in spaces resembling those found in syringomyelia, or by the formation of cystic spaces containing a thin fatty fluid resembling pus in appearance.

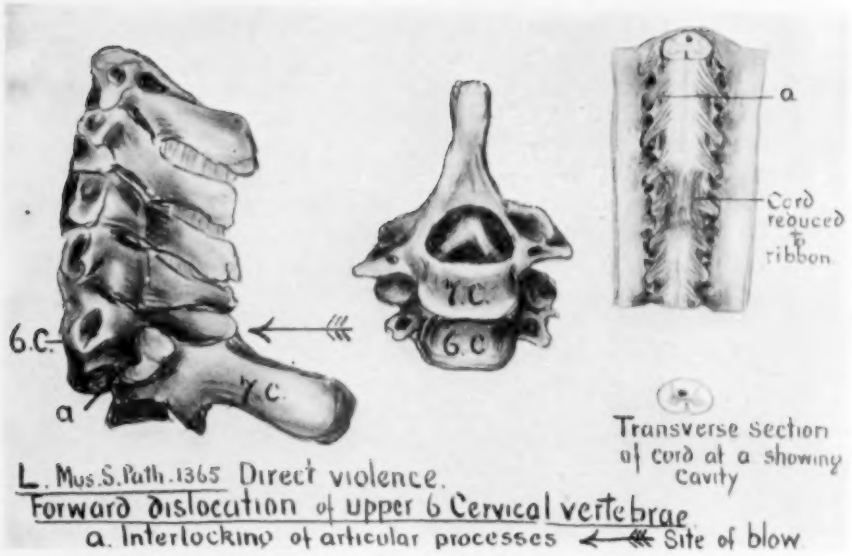

FIG. 13.—Case 8. Drawing showing deformity; narrowing of canal, and total crush of cord.

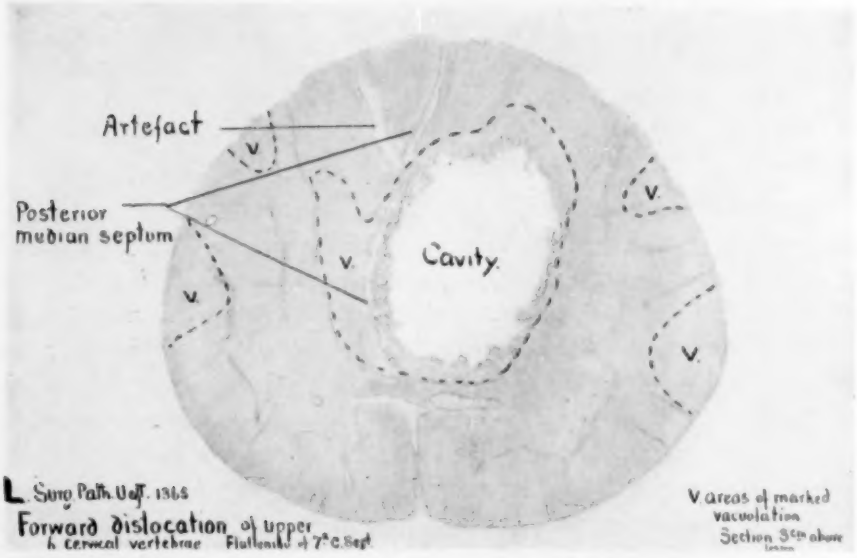

FIG. 14.—Case 8. Drawing of microscopic section 3 cm. above the lesion.

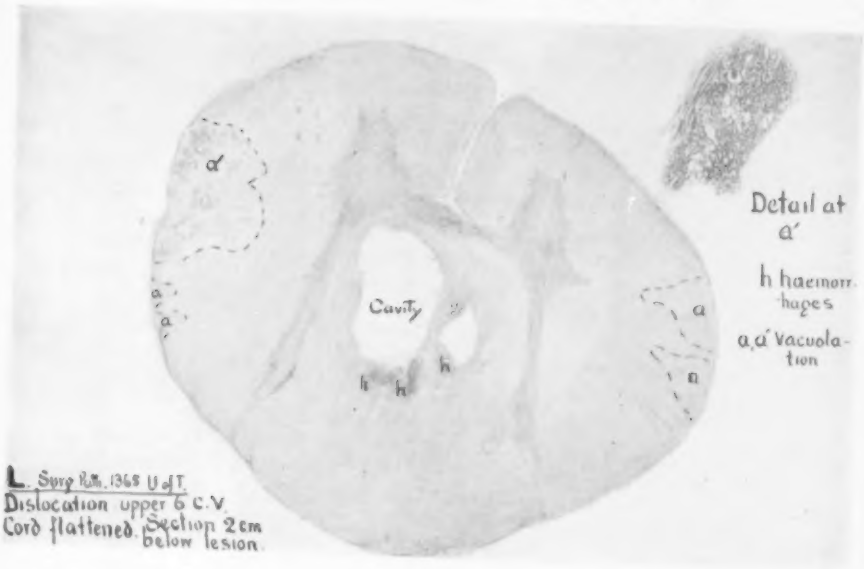

FIG. 15.—Case 8. Drawing of microscopic section 2 cm. below the lesion.

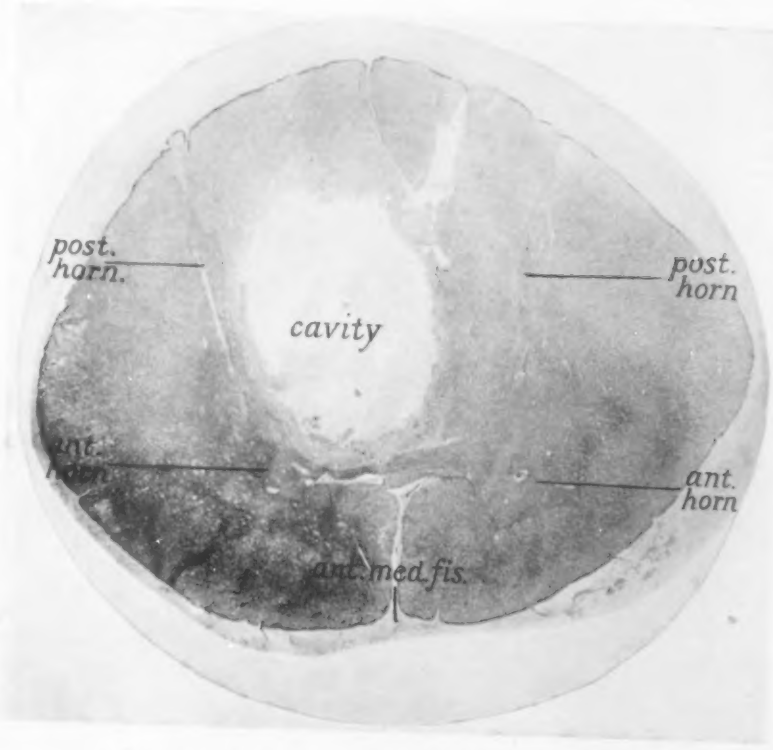

FIG. 16.—Case 8. Photomicrograph 3 cm. above the lesion.

GROUP IV, CASES LIVING SIX WEEKS AND OVER

CASE IX.—Museum No. 22 J. A museum specimen with practically no history (Fig. 17, A and B). The appearance of the bone and soft parts leads us to believe that the patient must have lived a considerable time after the accident. There is no sign of extravasation of blood anywhere. The body of the 11th thoracic vertebra is fractured obliquely. From this, the line of separation passes backwards between the 10th and 11th vertebræ ripping up the intervertebral disc, and tearing through the interspinous ligament. The cord has been crushed very severely along the line of separation. It is represented by a cavity with walls of pulpy tissue. Above and below the crushed segment conical areas of disintegrated tissue are seen. They occupy the centre of the cord and are shown in the photograph by a dark stippling. Their bases abut on the injured segment and their apices extend upwards and downwards to the middle of the corresponding vertebra. Opposite the middle of the body of the 12th thoracic, the centre of the cord is occupied by a small cavity. A similar one, much smaller, is seen above opposite the upper part of the body of the 11th. No microscopic sections were made of this specimen because we were afraid that the method of preparation had changed its minute character. It was prepared by freezing and sawing the spine and cord sagittally.

CASE X.—Museum No. 191 I. A museum specimen with a somewhat scanty history attached. The patient was admitted to the Sealy Hospital with symptoms of a complete transverse lesion of the spinal cord at the level of the 3rd thoracic segment. There was complete flaccid paralysis with absence of all reflexes and total anæsthesia below the lesion. The patient lived for several months. Bed-sores developed and severe cystitis set in before death.

The specimen (Fig. 18) shows a transverse crush of the cord with permanent flattening for a considerable distance. The flattened portion, which is as long almost as a vertebral body, is tape-like and consists almost entirely of pia mater. A microscopic section at this level (Fig. 19) shows merely granular debris and a few nerve roots surrounded by a sheath of pia. Immediately above and below the constriction, the cord shows a bulbous enlargement.

Sections through these areas show serious destructive changes. The section above the lesion (Fig. 20) shows complete destruction of the anterior cornu and the anterolateral portion of one side of the cord and partial destruction of the anterior cornu of the other side. In the section below the lesion (Fig. 21) a similar but less extensive area is seen. Œdematous areas are distributed throughout both sections.

CASE XI.—O. G. Sealy Hospital, No. 39013. Autopsy No. 723. The patient fell into the hold of a ship and sustained a fracture-dislocation of the 7th thoracic vertebra, attended by symptoms of a total transverse lesion. He lived for 51 days, and eventually succumbed to sepsis of the kidneys and bladder. No operation was performed on the spine.

At the autopsy there was a marked kyphotic curve in the mid-dorsal region. A fracture was found situated in the body of the 7th thoracic vertebra. The spinal canal was considerably narrowed at this level. The appearance of the cord is shown in Fig. 22. The cord was severely crushed and flattened over an area almost equal to two vertebral segments. The dura and pia mater were so firmly adherent that they could not be dissected away from one another and from the cord without tearing. The cord was reduced to a narrow band of tissue of firm consistence contained in the tube of dura and pia. Several elongated narrow cavities which contained a grumous fluid are present in its substance. There were no signs of hemorrhage beyond a general dark staining of the crushed nervous tissue. The appearances are identical with those found at the time of operation, in Case XIII.

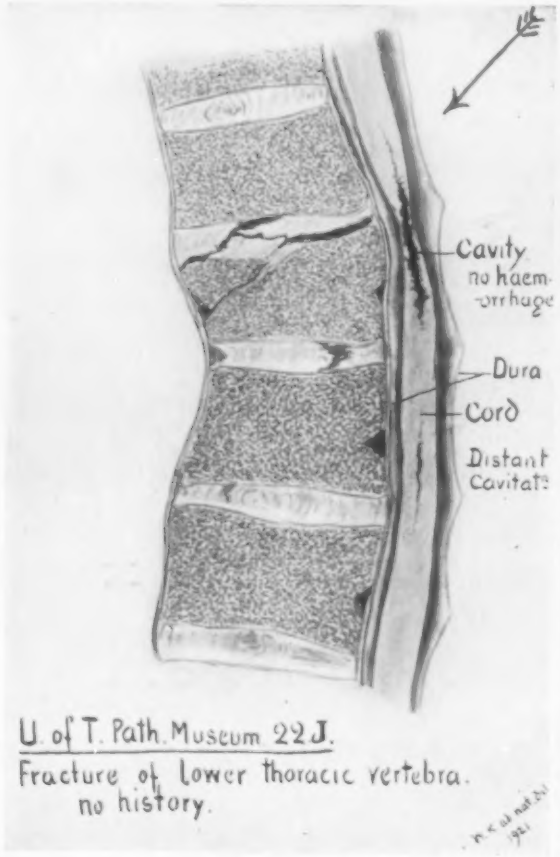

FIG. 17 A.—Case 9. Drawing showing vertebræ after recoil; cavitation in the cord.

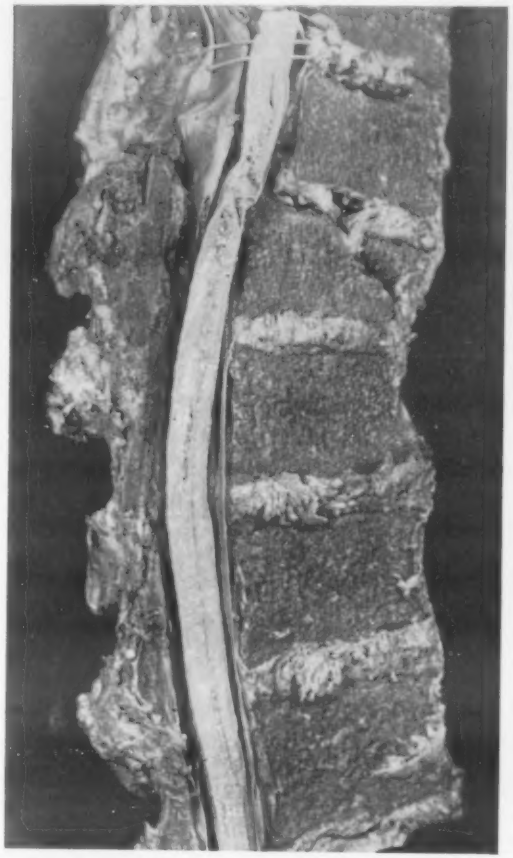

FIG. 17 B.—Case 9. Photograph of cord in situ.

FIG. 18.—Case 10. Cord flattened at site of lesion; increased in size above and to a less extent below.

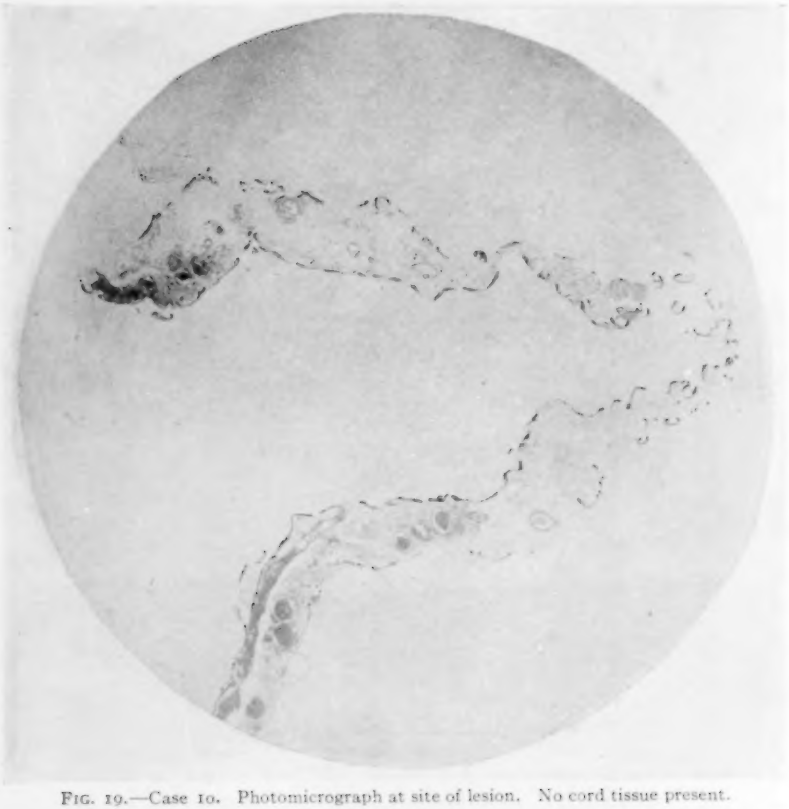

FIG. 19.—Case 10. Photomicrograph at site of lesion. No cord tissue present.

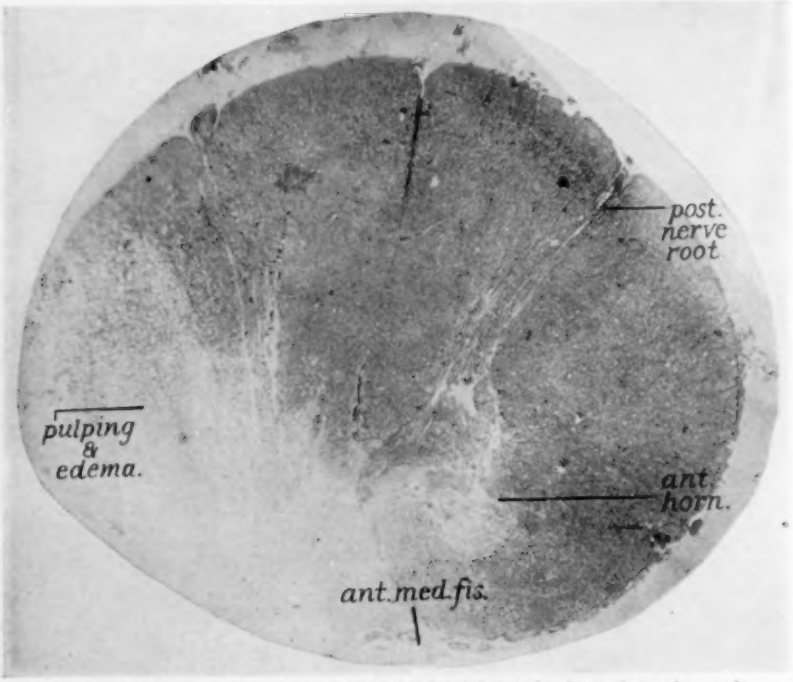

FIG. 20.—Case 10. Photomicrograph showing pulping and œdema above the crush.

Case XII.—B. M. Sealy Hospital. History No. 956. Surg. Path. No. 1195. The patient was admitted to the Sealy Hospital on March 4, 1920, totally paralyzed and anæsthetic in his lower extremities the result of a fall from a height of 20 feet. The 11th and 12th thoracic spinous processes were very prominent. X-ray examination showed a fracture of the body of the 12th thoracic vertebra. Both legs were completely paralyzed and flaccid with complete absence of all reflexes.

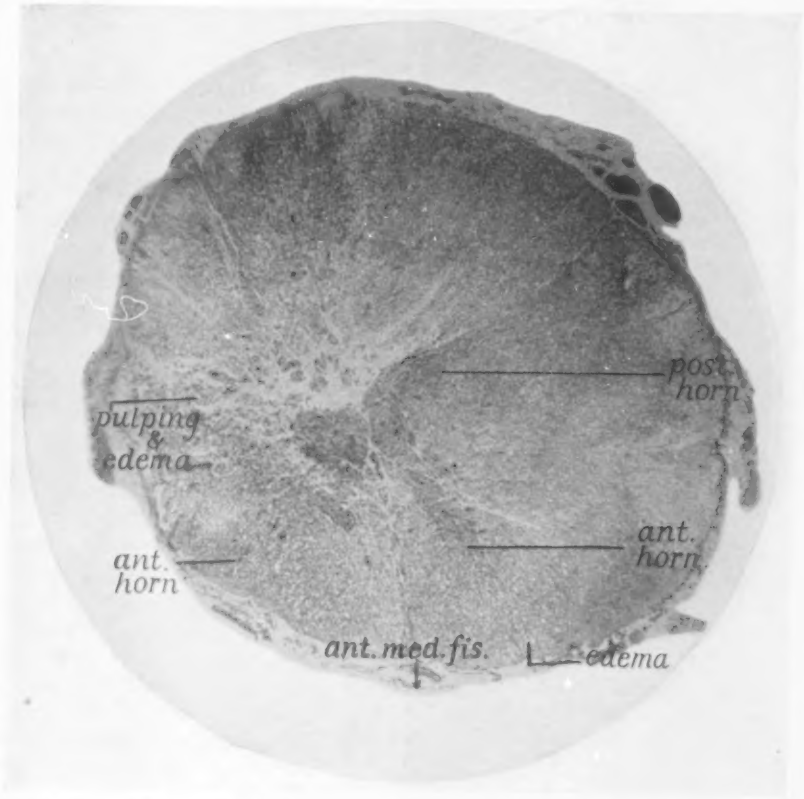

Fig. 21.—Case 10. Photomicrograph showing pulping and œdema below the crush.

Anæsthesia was complete to all forms of sensation up to a point on the front of the abdomen about 3 inches above pubic symphysis and laterally to the level of the iliac crests. There was no control of the bladder and rectum. In time bedsores developed on the buttocks, heels, toes and penis. There was no priapism. Death occurred 4½ weeks after the injury, from cystitis and renal sepsis. There was never any sign of return of the reflexes in the paralyzed limbs.

The autopsy showed forward displacement of the 11th thoracic vertebra associated with a fracture through the body of the 12th. The spinal canal was considerably narrowed. The spinal cord (Fig. 23) was completely crushed at this level, and the crushed cord is represented by a flat tape-like band of tissue lying in a sleeve of pia mater. The pia mater was not torn. The dura mater was intact and was not adherent to the pia. Sections of the cord above and below the lesion showed pulping and cavitation similar to that seen in Case VIII, but more extensive.

Case XIII.—J. R. Sealy Hospital. No. 132972. On December 28, 1922, the patient was pinned underneath an overturned motor car. When extricated the lower

extremities were completely paralyzed and he had lost control of the bladder and rectum. He was admitted to the Sealy Hospital on March 13th. Examination showed that he was suffering from symptoms of a complete transverse lesion of the spinal cord below the level of the 12th thoracic segment. Sensation was present as low as the symphysis pubis in front, and laterally a slight distance over the iliac crest. All the reflexes below the abdominal were completely lost. Bed-sores were present over the sacrum and heels. Urinary retention, which required catheterization at first, had now given way to dribbling. The bladder was not paralyzed, but overflowed. It did not contract in response to tickling of the inner side of the thighs. Paralysis and anæsthesia were complete in both legs. The muscles were flaccid and wasted. No reflexes of any kind were present. Anæsthesia was absolute to every variety of stimulus. The skin was dry and scaly.

FIG. 22.—Case 11. Dura, arachnoid and pia firmly adherent at the site of lesion; no cord tissue demonstrable here.

X-ray examination showed a dislocation forwards of the 12th thoracic vertebra on the 1st lumbar. The deformity was so excessive that the posterior edge of the body of the upper vertebra was in line with the anterior edge of the vertebra below. Under the skin of the back one could feel distinctly the upper articular process of the 1st lumbar.

The patient begged so earnestly for operation that I, against my better judgment, consented to perform a laminectomy. I removed the laminæ and spinous processes of the 11th and 12th thoracic and the 1st lumbar vertebræ. The laminæ and ligamentum subflavum of the 12th thoracic, and to a less extent, those of the 11th were firmly adherent to the dura mater. At the lower border of the lamina of the 10th thoracic the dura looked fairly normal. Underneath the lamina of the first lumbar the dura was also normal. The dura mater was opened in the middle line from end to end. The normal subarachnoid space was opened above at the lower border of the lamina of the 10th thoracic. The dura was quite adherent to the pia opposite the body of the 11th and densely adherent opposite the body of the 12th. Opposite the first lumbar the subarachnoid space was not obliterated, but it contained very little fluid. While trying to separate the adhesions between the dura and pia opposite the body of the 12th thoracic a cystic cavity about half an inch long was opened from which flowed a turbid fatty looking fluid-like pus. The cystic cavity occupied the middle of the flattened band of tissue which represented the crushed cord. It was unrecognizable as nervous tissue. Over an extent of almost two spinal segments the cord had been destroyed. The lumbar enlargement was recognizable but somewhat smaller than normal.

As far as could be ascertained by the naked eye the cord was completely destroyed opposite the body of the 12th thoracic vertebra. Nothing had been gained by the operation, as was surmised beforehand. Since the operation no change whatsoever has occurred, either in motion or sensation, or the return of reflexes.

Remarks.—All the cases in this group had lived a considerable time since the accident. We are uncertain about the exact time in Cases VIII and IX, but from the appearance of the soft tissues in Case VIII and from the autopsy notes in Case IX, several months must have passed between the history and death. Marked cavitation is seen in Case VIII, and the conical areas of disintegrated tissue show up clearly. Permanent narrowing of the canal had resulted, in Cases IX, X, XI and XII, from failure of the vertebræ to recoil. In each of these cases continuous pressure had moulded the crushed cord into a flattened tape-like mass or had forced it completely out of the sheath of pia mater. It seems probable that soft diffluent cord will flow backwards into the sheath of pia mater as soon as pressure is relieved by recoil of the bones, but that continuous pressure, such as exists where the deformity is permanent, will produce permanent flattening. In Case VI, diffluent cord had refilled the tube of pia from which it had been squeezed. Nevertheless it was disorganized completely, and for a considerable distance above and below the lesion cavities filled with blood and disintegrated nervous matter were found. If the sheath of pia mater is torn diffluent material will frequently flow out of the pial sheath into the subarachnoid space. In such cases, if the dura mater is opened at operation or at autopsy, the diffluent disintegrated cord tissue will ooze out of the opening. The microscopic appearance of sections taken through the crushed area shows fissures which traverse the cord substance in the direction of the exit of the pulped tissue through the torn pia mater. The arrangement

FIG. 23.—Case 12. Cord tissue squeezed up and down; empty tube of pia at site of lesion.

of the diffluent cord in parallel areas also suggests lines of flow or currents. Such appearances are shown in Figs. 7, 24 and 25.

In Case XII we had an opportunity of seeing at operation a crushed cord identical in most respects with those described in Cases IX, X and XI. A period of a little more than three months had passed since the injury and during this time the disintegrated nervous tissue had liquefied and lay in a cavity situated in the flattened band of tissue representing the crushed cord. It showed convincingly the futility of operative interference, because there was not a shadow of doubt that the destruction was absolute. The most hopeful and sanguine surgeon could hardly have persuaded himself that relief of pressure would produce a beneficial result.

By the courtesy of Adjunct Professor Joseph F. McVeigh of the Department of Anatomy, I have examined the spinal cords of several dogs which had been crushed experimentally with a view to causing a lesion as nearly as possible like that which would follow a fracture-dislocation. In each experiment the cord was exposed by nibbling away the spine and laminæ of one or two thoracic vertebræ. Through the intact dura mater the cord was crushed either with the tip of a finger or the handle of a scalpel. In some of the experiments pressure was continued until the finger or handle of the scalpel was arrested by the vertebral bodies. In others less severe force was used. No attempt was made to measure the force employed, because the object of the study was merely to observe the changes that resulted in the traumatized zone and in the contiguous areas. We found in all cases that the changes were identical with those seen in human cords. The production of cone-shaped areas of destruction above and below the lesion when the crush was complete, the widespread hemorrhagic extravasation, the liquefaction of the disintegrated nervous tissue and the production of cavities were all observed. Moreover we were able to follow the separate steps of the degenerative changes because the regulation of the age of the morbid processes was completely under our control.

In Fig. 24 (dog 6) a curious distortion of the posterior half of the cord has occurred. The section was taken at the level of a crush in which only slight force had been employed. A slight opening had then been made in the dura mater through which clear cerebrospinal fluid flowed. The dog was killed 32 hours afterwards and up to the time of death the hind legs were completely paralyzed. The section shows that the posterior surface of the cord is drawn out somewhat like the stem end of a pear. The posterior columns and cornua are seriously broken up, and seem to be flowing backwards in lines resembling currents of lava. The appearances suggest strongly that the flow of disintegrated tissue is towards the hole in the dura mater which was made at the time of operation. The same appearances are shown in the human cord described in Case IV.

In Fig. 25 (dog 1) a considerable degree of force was used by the tip of the finger. The dog was killed at the end of 41 hours. The specimen taken through the lesion shows an excessive degree of pulping. It occupies all the posterior columns and the adjacent parts of the posterior horns and the gray commissure. Wide branching fissures extend in every direction between masses of disintegrated tissue. There is marked œdema in every other part of the section, particularly intense at the periphery of the lateral columns. The pulped area is permeated

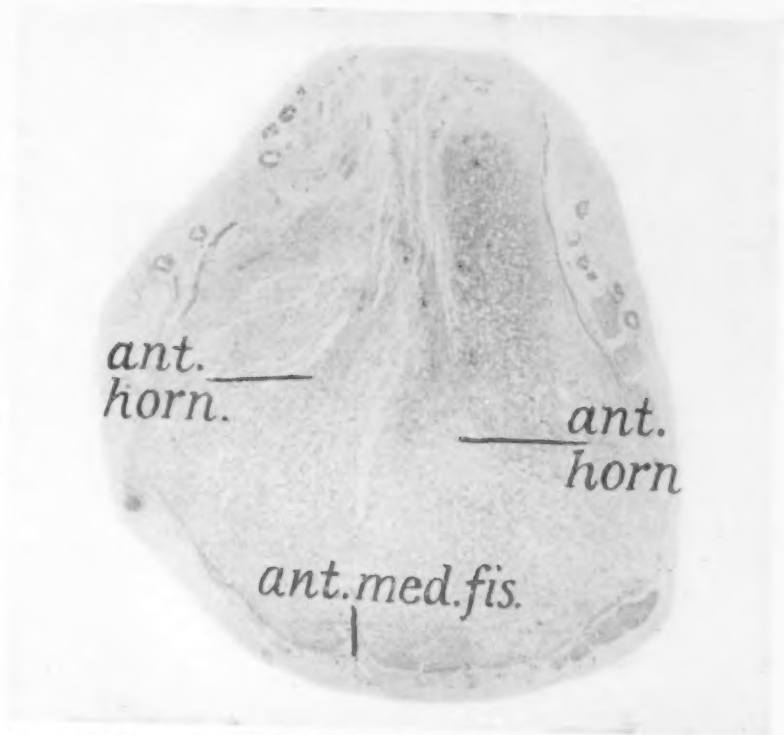

FIG. 24.—Dog, killed 32 hours after partial crush. Cord tissue flowing towards opening in dura.

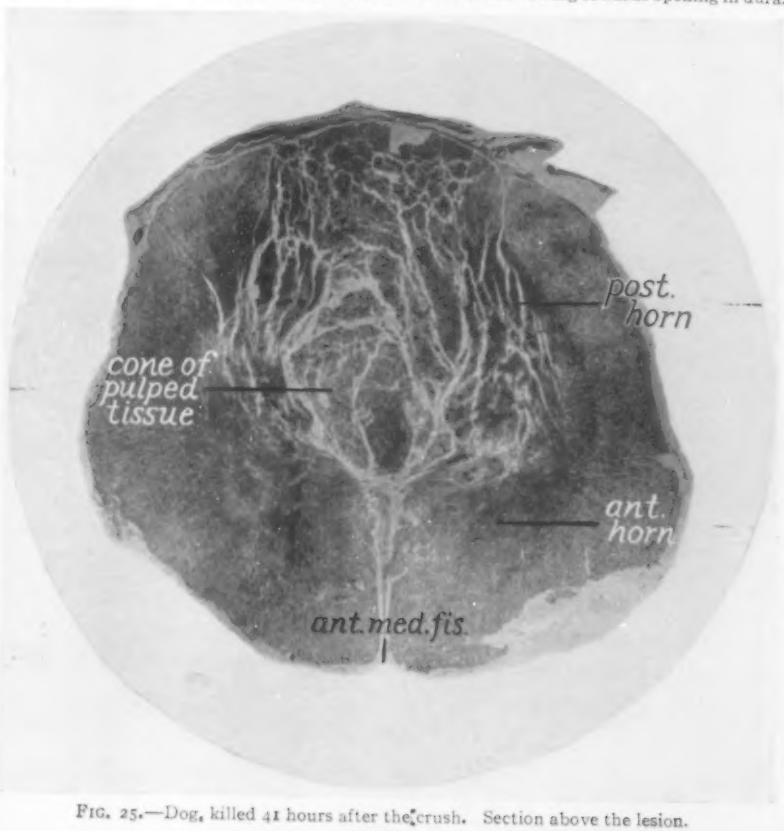

FIG. 25.—Dog, killed 41 hours after the crush. Section above the lesion.

with extravasated blood and is a transverse section of the cone previously described. It is so completely cut off from the unshattered part of the cord which surrounds it, that liquefaction and cavitation would probably have resulted if the dog had lived long enough.

In Figs. 26 and 27 (dog 2) we are able to show the later changes. The dog was killed at the end of 2 weeks. The cone-like area of destruction has undergone liquefaction and absorption resulting in cavitation. The cavity is situated in the posterior cornua abutting on the gray commissure. The appearances are identical with those shown in the human cord in Case VIII.

In Fig. 28 (dog 5) a moderate degree of force was used with the handle of a scalpel. The dog was killed at the end of 20 hours. The distortion is great. Hemorrhage is present in both anterior cornua. The cord resembles closely the human cord in Case III.

In undertaking this study I was anxious to find out if the area of destruction of nervous tissue was absolute from the moment it occurred or whether it was progressive; in other words, whether morbid changes occurred in the neighborhood of the extravasations of blood which would ultimately lead to the death of nervous elements which were unhurt originally; and further, if such changes occurred whether it was possible to arrest them by operative procedures. It is unnecessary to discuss the question of regeneration of axis cylinders and the other intrinsic nervous elements of the cord, because no evidence has ever been advanced either from a pathological or clinical standpoint to support such a belief. We must accept finally the statement that regeneration never occurs.

Touching the question of progressive destruction, it is a very difficult matter to arrive at a sound conclusion, because the changes that occur are of an entirely different character to those met with after injuries of other structures of the body. The phenomena of active inflammation which always occur during the healing of gross tissues are never seen. There is nothing that resembles in the least degree the circulatory and cellular changes which are present in tissues undergoing repair. The processes, on the contrary, are of a passive nature, consisting of œdema followed by liquefaction and vacuolation. Œdema seems to occur inevitably, sooner or later, in or around the areas of extravasated blood. We found it present to a limited degree in one of the dogs at the end of 8 hours. It was always present in dogs who survived the crush for 24 hours. In our human cords, however, we found that it was absent in Case III, who lived 24 hours, and in Case IV, who lived about 40 hours. In all the cords of patients dying at a later date, œdema was seen in every part of the section, more intense in the areas of extravasation of blood; and, where life had been prolonged for several weeks, clearly demonstrable in the periphery of the cord. The significance of œdema is not clear. Some writers such as Frazier and Allen believe that it is the direct result of circulatory changes produced by ruptures of small arterioles, and that it is essentially progressive and destructive in its tendencies; in other words that nerve tracts that have escaped destruction by the primary injury may be destroyed later on by œdema.

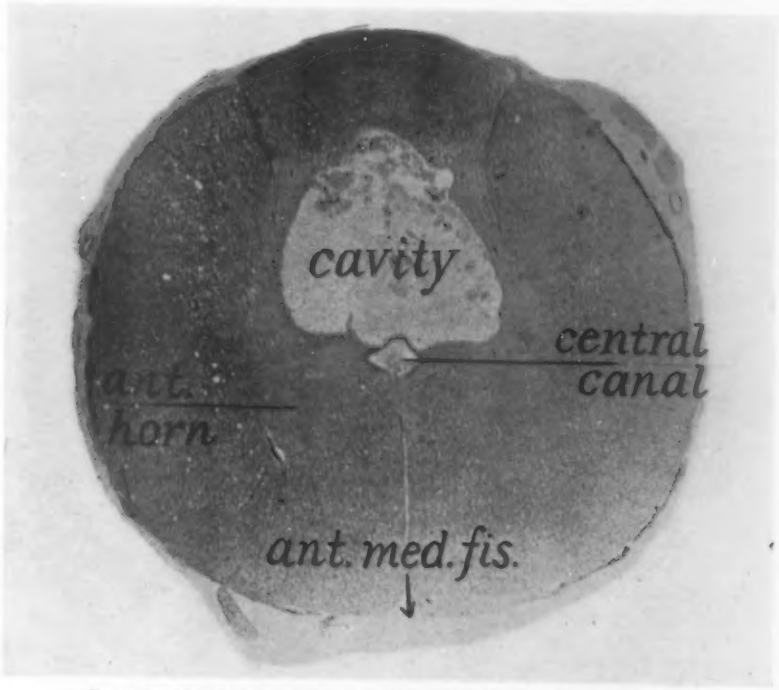

FIG. 26.—Dog, killed 2 weeks after the crush. Cavity above the lesion.

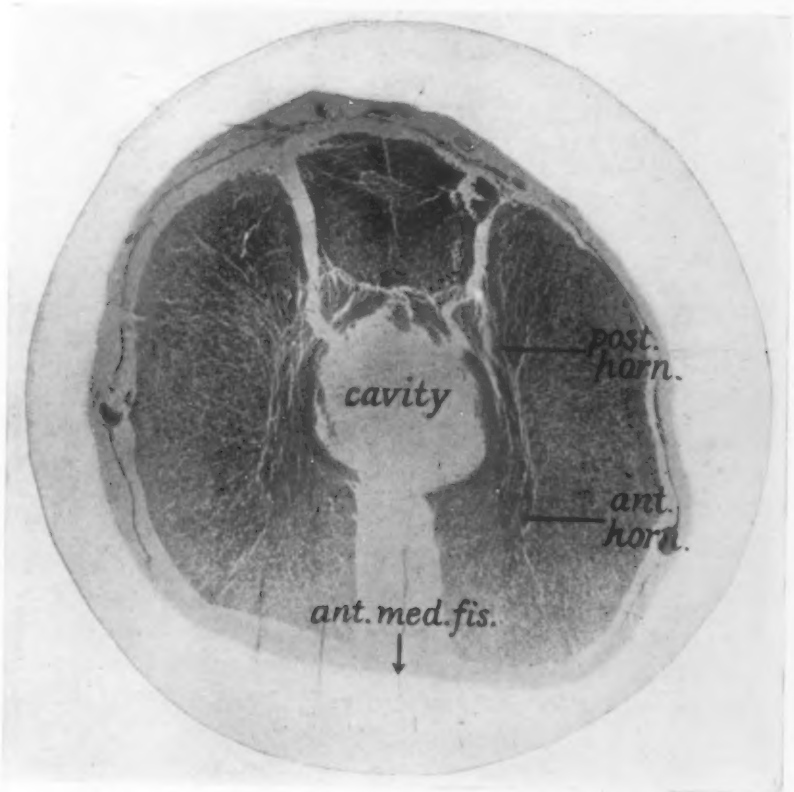

FIG. 27.—Same dog as Fig. 26. Section below the lesion. Cf. Fig. 16.

The experimental observations of Allen on the changes following contusion of the spinal cords of dogs led him to believe that the extravasations of blood occurring in the substance of the cord and under the pia mater were progressive to a certain point and that œdema made its appearance in the substance of the cord in fifteen minutes. An incredibly short time! He believed that

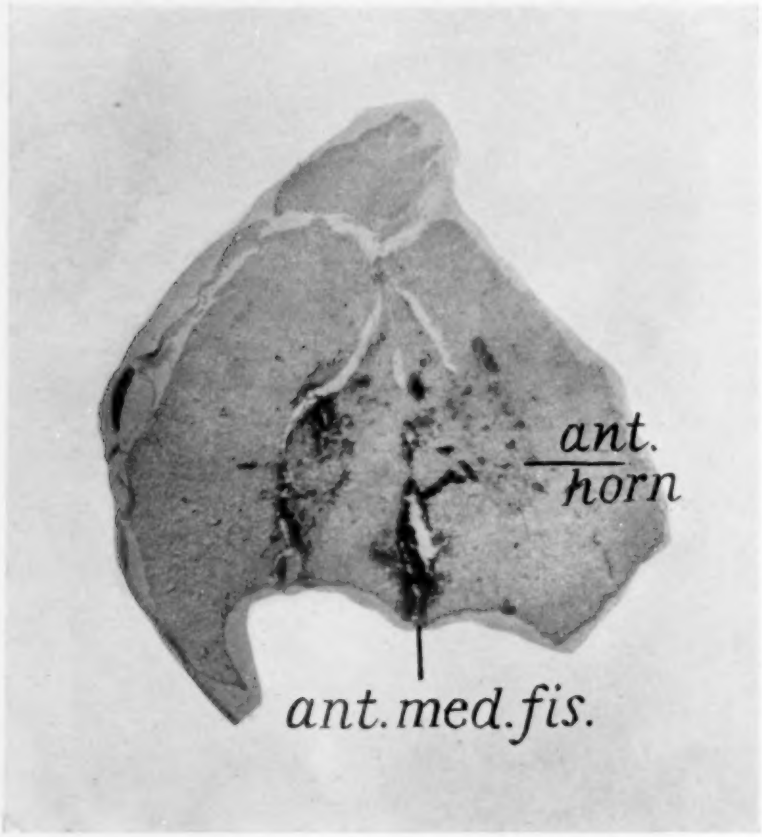

FIG. 28.—Dog killed 20 hours after partial crush. Deformity and hemorrhage at site of lesion. Cf. Fig. 5.

hour by hour disruption of the cord progresses, aided by hemorrhage and œdema, and that the condition of the injured segment is very much worse three or four hours after the accident than it is, say, at the end of the first hour. From these observations he concluded that, if the secondary changes in the cord, *viz.*, œdema and hemorrhage, could be prevented, many cases of total transverse lesion could be averted, and partial recovery of function secured. To this end he advised an incision of the cord through the contused level to drain away the effused blood and relieve the intramedullary pressure. The incision employed was carried longitudinally through the injured segment exactly in the middle line of the cord, separating it into two halves. He found

in cords subjected to this incision two hours after being crushed by a force which had been standardized so as to produce a complete transverse lesion, that he had been able to arrest the disintegration of tissue such as invariably occurs in non-operative cases. The experimental work on which these conclusions are based was carried out so accurately that the deductions are apparently logical and justified. It is difficult, however, to accept them unreservedly for two reasons; firstly, because paralysis and anæsthesia reach their maximum immediately after the injury, and are seldom of the progressive type; and secondly, because the changes seen in a crushed cord after incision are open to an entirely different interpretation.

The first objection is on clinical grounds. It is true that we occasionally see cases in which paralysis and anæsthesia are progressive, but they are the exception and not the rule. The following are examples. We have recently had under our care a patient whose motor paralysis pointed to a transverse lesion of the cord at the level of the seventh cervical segment. Sensation to pin prick was present in isolated areas distributed irregularly over the chest, abdomen and legs. The superficial abdominal reflexes were present but the cremasteric was absent. All the deep reflexes of leg were absent. There was no fracture of the spine and no deformity of the spinal column. The cord symptoms followed a severe contusion over the seventh cervical spine. A few days after admission the areas of sensation and the superficial reflexes disappeared and the upper limit of anæsthesia became definitely fixed. No change occurred afterwards up to the time of death. We have also histories of several cases of complete transverse lesions resulting from fracture-dislocation associated with deformity, in which the loss of motion was instantaneous, but sensation was not lost until later (Case V). Another patient, whose sixth cervical vertebra was dislocated forwards during a football game, asserted that he felt distinctly the pain caused by the forcible ripping of strips of adhesive plaster from his insteps when his shoes were removed.

Nevertheless, in complete transverse lesions paralysis and anæsthesia are usually definitely defined immediately after the crush. There may be some difficulty for a day or two in outlining accurately the upper limit of sensation by reason of the profound spinal shock or the fact that the lesion is not linear but diffused over several segments; but, when spinal shock disappears, the limits of paralysis and anæsthesia become definitely and permanently fixed. In partial lesions there is frequently a period during which spinal shock is so profound that the injured segment is unable to transmit any impulse through it. Such cases are often mistaken for examples of total transverse lesion until the return of function shows that some tracts have escaped destruction. Far from noticing signs of progressive destruction in such cases, recovery up to a certain point is smooth and uninterrupted.

The second ground of objection deals with the proper interpretation of the changes seen in a contused cord after a median incision. In his original article, Allen shows transverse sections of two injured cords. In one (Fig. 1,

Allen) no incision had been made and the cord was removed six hours after the injury. In the other (Fig. 2, Allen) a median longitudinal incision had been made two hours after the injury and the cord removed four hours afterwards. The first cord (not incised) shows extensive destruction of both the posterior cornua and both posterior white columns. The pia mater is intact and the general shape of the cross section is not much changed. The injured area for the most part is composed of disintegrated diffluent matter very loosely connected with firmer uninjured nervous tissues surrounding it. The second cord (incised) is considerably flattened laterally. Both posterior horns are missing and the space occupied originally by the posterior columns is almost obliterated by the collapse of the lateral columns towards the median line. A pyriform cavity apparently filled with blood occupies the unobliterated part of this space. The incision into the disintegrated area appears to have relieved pressure and to have allowed the diffluent material to escape. This has evidently been followed by collapse of the cord and approximation of the lateral columns, resulting in a decrease in the lateral diameter of the cord. There is no doubt that the substance of the cord is clearer and better preserved in the incised than in the non-incised specimen, but there is such a decrease in the transverse area of the cord that we cannot help feeling that the diffluent tissue which escaped from the incision carried with it a considerable amount of nervous tissue which was not seriously injured, and which might have been expected reasonably to have recovered if it had not been disturbed. We have previously pointed out both in human and dog's cords, that the area of disintegrated material is cone-shaped and that the apices of the cones are situated at a considerable distance above and below the level of the lesion. The cones consist of diffluent material, the quantity of which is quite considerable. It forms the thick creamy material which flows out of the pia mater when the cord is exposed. While it lies in the substance of the cord it acts as a support to the uninjured tissue surrounding it. Evacuation removes the support and the walls of the cavity cave in like the sides of a sand pit or the banks of a river when the waters recede. On these grounds we believe that evacuation is not without its drawbacks and dangers.

Even admitting that incision usually produces the beneficial results claimed for it *experimentally*, we must not forget that the method employed to crush the cord of a dog injures the posterior columns more frequently than any other part, and that they occupy the only really accessible part of the cord. On the other hand, it is impossible to drain the anterior and lateral regions of the cord through a median posterior cut; and we have found these areas not infrequently crushed in human cords. (See Cases III and IX.) Allen himself emphasized the fact that the progressive destructive changes reached their maximum in about four hours, and that after this time the picture did not change materially. Therefore it follows that the crushed cord must be incised immediately after the injury if we are to expect beneficial results. At the end of four hours the mischief would be complete and incision would then be futile.

One can imagine that a procedure hedged around with such restrictions must have a very limited field of usefulness.

At the present time there seems no probability of agreement as to whether operation is either advisable or justifiable. Some surgeons believe that operation should be performed in every case as soon as possible, in the hope of finding some conditions, such as hemorrhage or deformity, the removal of which will prove of benefit to the patient. Others never operate under any circumstances because they believe that it is useless to expect injured cord to recover. Extreme views are seldom wise. The middle course is always safest (in medio tutissimus ibis). I have personally for many years been strongly opposed to operation as a routine practice. It is often unsafe, rarely justifiable and usually futile. Except in the rare instances where median incision of the cord is the objective, mere exposure of the injured segment is all the surgeon can hope to accomplish, because deformity is seldom persistent and massive hemorrhages do not occur. I believe that the only positive indication for operation is the persistence of deformity of such a degree as to justify the assumption that the cord is subjected to pressure. Even with such strict limitations, incomplete lesions alone would be benefited. If it were possible to distinguish with certainty, complete from incomplete transverse lesions in the early period, the problem would be solved. At the present time we are unable to decide and consequently we must either wait days or weeks for unequivocal signs or operate early in the hope of affording relief. I firmly believe that waiting is the best and safest course.

REFERENCES

Allen, A. R.: Journal of Nervous and Mental Diseases. March, 1914.
Ibid: Journal of American Medical Association. September, 1911.
Frazier, Chas. H.: Surgery of the Spine and Spinal Cord.
Horrax, Gilbert: British Journal of Surgery. July, 1919.
Thorburn, Wm., and Richardson, George: British Journal of Surgery. April, 1919.
Thorburn, Sir Wm.: British Journal of Surgery. October, 1920.
Ibid: A contribution to the Surgery of the Spinal Cord. 1889.

ACTINOMYCOSIS*

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My attention has been directed to this subject by a recent case which, going on to a fatal ending, allowed of a post-mortem, which revealed the origin of the disease about the appendix. It is the latest of a series of four cases which I have had, and in reporting these I desire particularly to present this case of actinomycosis of the appendix.

The ray fungus which causes actinomycosis originates in the rust sometimes found on grain and grasses. It is common amongst cattle, producing lump-jaw, and occasionally it is found in man, most frequently in the cervico-facial region, and less often in the region of the appendix. Rarely it is found in the lung or liver, and a few cases are on record where it attacked the central nervous system.

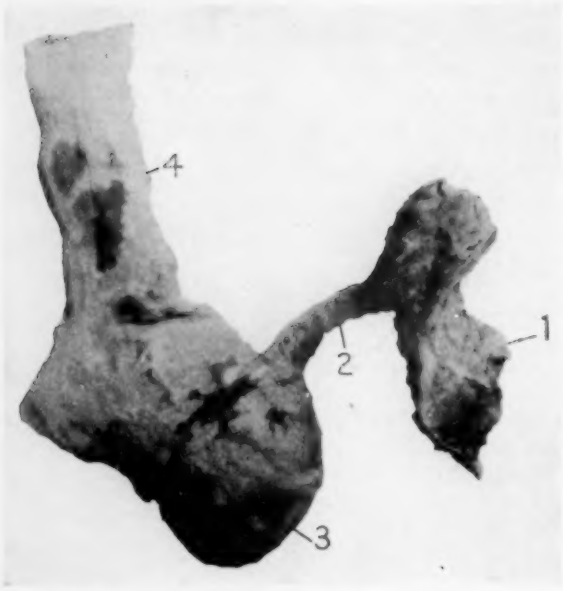

Fig. 1.—Appendix and wall of abscess. 1. Wall of abscess. 2. Appendix communicating with abscess cavity. 3. Cæcum. 4. Terminal portion of ileum.

The conditions under which the ray fungus—the actinomyces bovis—attacks man are not quite clear, for a study of all recorded cases gives one the impression that while in America it occurs most frequently in those localities where the disease is most prevalent in cattle, in England it bears no such relation; and the disease is by no means confined to millers and farmers, as the text-books would lead one to believe, but is seen amongst all classes. Men are affected much oftener than women, and the age incidence is between twenty-four and forty-five.

The routes of infection are from carious teeth or the throat to the cervico-facial region, as shown by the researches of Lord,[1] and from the lumen of the intestine in the abdominal variety, as pointed out by Wright.[2] Case I, here reported, which seems to show the appendiceal origin, tends to confirm the

* Read before the American Surgical Association, June 2, 1923.

early views of Ransom [3] and later those of Battle and Corner [4] and Cope.[5] The spread of the disease occurs by continuity of tissue and never by the lymphatics. The abdominal variety frequently shows spread to the liver in the form of a portal pyæmia.

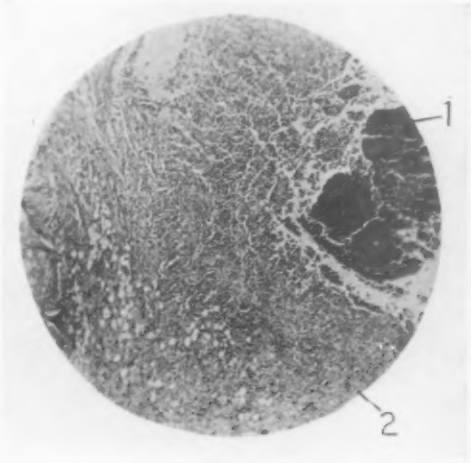

FIG. 2.—Low-power view of wall of abscess cavity showing colonies of ray fungus. 1. Colonies of actinomycosis. 2. Inflammatory reaction.

The disease is seldom recognized in the early stages, it being mistaken for one of the commoner diseases which it so closely resembles, until, in the majority of cases, it has a firm foothold in the tissues. The diagnosis is rendered difficult by the insidious onset and the essential chronicity of the lesions, but there are definite symptoms in each type of the disease which, when borne in mind, help toward avoiding the too common error of thinking it a case of tubercular glands, Hodgkin's disease, sarcoma or appendicitis.

The cervico-facial type occurs in about eight out of ten cases, and while the swelling itself may not present any early distinctive features, the persistence of trismus independent of the size of the lump or any nerve involvement is pathognomonic. Later when the swelling, which is smooth, hard and painless, without any definite boundary, becomes hyperæmic, softens in places, breaks down discharging a little thick pus, heals and becomes puckered, and presents alongside the puckered areas new formed eminences going on to pus formation, the picture is unmistakable, and thorough and repeated search should be made by the surgeon or his assistant for the organism in the pus. A sinus may be found extending out from a neighboring carious tooth, as in Case II. The pus contains minute sulphur-like granules in which the ray fungus is seen when examined under the microscope. When these are found the diagnosis is no longer questionable, and active treatment is instituted.

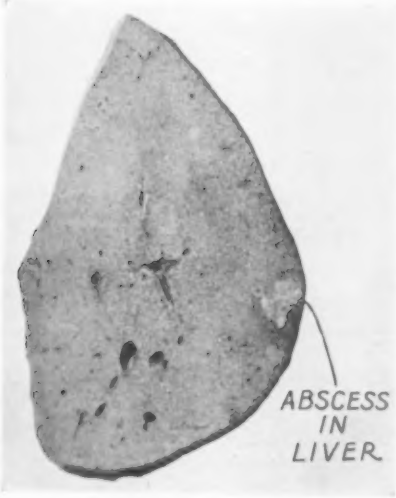

FIG. 3.—Liver showing actinomycotic abscess formation.

In the abdominal type the diagnosis is not so easy, and one is very prone to mistake the condition for subacute or occasionally acute appendicitis. The mistake is not in considering the case one of appendicitis, for inflammation and actinomycotic involvement of the appendix is actually present, but in overlooking the nature of the infection which spreads to involve the retroperitoneal tissues, giving symptoms which identify the disease. The woody hardness of the tissues invaded by the actinomyces bovis accounts for one symptom which stands out as characteristic. It is the flexion of the right leg at the hip, due to involvement of the psoas muscle, and pain on attempting to extend the thigh. When this symptom is present and is accompanied by those which point to inflammation of the appendix or cæcum, and there are the physical findings of a painless hard tumor in the right iliac fossa, which has developed too rapidly to be a cancer and too slowly to be an appendiceal abscess, no involvement of the peritoneal cavity and only a moderate degree of constitutional symptoms, one should expect actinomycosis. The absence of any lesion of the spine and fluctuation found in a psoas abscess rules out Pott's disease. Brockman [6] groups the symptoms into four stages—(1) Varying abdominal symptoms mainly confined to the right iliac fossa, (2) The presence of a tumor in that location, (3) Sinus and fistula formation, and (4) Repair or dissolution. In the later stages of the abdominal types, when sinuses have formed, the diagnosis may be made by isolating the sulphur granules from the discharge.

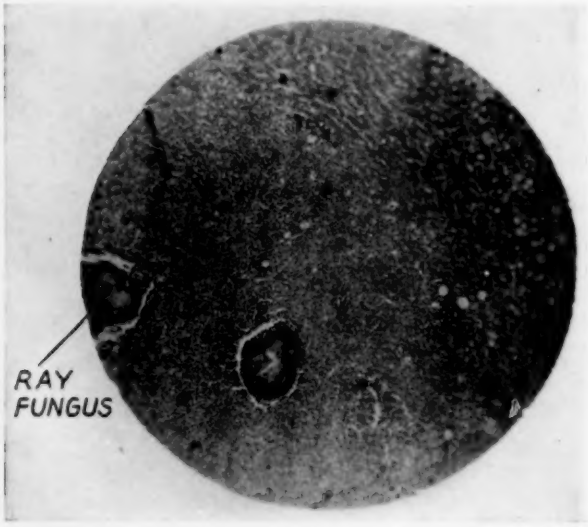

FIG. 4.—Section from liver showing ray fungus with abscess formation.

Occasionally the disease may spread by continuity of tissue to involve the scrotum while remaining more or less hidden within the abdomen. Such cases are extremely misleading. Case I was of this type.

The prognosis depends upon the location and duration of the disease. In the cervico-facial lesion an early diagnosis gives good hope for a complete recovery, while in the abdominal type the mortality rate is 80 per cent.

Treatment resolves itself into local and general. The local treatment differs with the location of the disease. In the cervico-facial type total excision is desirable and usually possible. Along with excision, cauterization of the

tissue should be employed. The X-ray and radium have been used in the early stages of the cervico-facial type with varying success. In the abdominal type simple incision with drainage gives the best results. Curetting should not be undertaken.

Constitutionally the best success results from repeated large doses of potassium iodide. As much as 100 grs. three times daily may be given. Case II took 320 grs. daily for nearly a month. Along with this, autogenous vaccines of both the actinomyces and any accompanying infection, may be used. The vaccines have not proved of much value in the treatment. Bevan[7] advocates the administration of copper sulphate ¼ to 1 gr. three times daily along with the potassium iodide, and local irrigation of sinuses with a copper sulphate solution 1 per cent. This treatment has also been used at the Mayo Clinic.[8] Fresh air, sunshine and moderate exercise when possible are very important in the constitutional treatment.

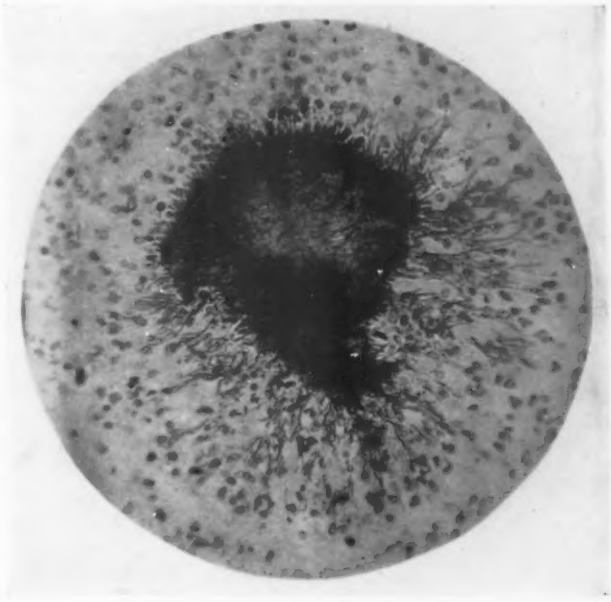

FIG. 5.—High-power view of the ray fungus showing filaments and clubs.

CASE I.—Mr. P. L. Age fifty-one. Had been in the railway service practically all his life. The present trouble began with acute abdominal cramps and diarrhœa. A few days later a swelling appeared in the right side of the scrotum, and a diagnosis of strangulated right inguinal hernia was made. The scrotum was opened by his local physician and a quantity of very foul smelling pus (with a fecal odor) was evacuated. In spite of this his temperature remained high and he became delirious.

When first seen by me on October 1, 1922, the right side of the scrotum was greatly swollen and the testicle had herniated through an opening in the skin. The opening was enlarged and the finger passed up to the external abdominal ring and freer drainage provided. On examining the abdomen there was no rigidity or tenderness in the right iliac fossa. There was considerable immediate improvement following freer drainage, but in a few weeks time he commenced to go downhill again, and on November 30, slight fullness having been noticed in the right iliac fossa, with flexion of the right thigh, Beck's paste was injected into the sinus and an X-ray made, which showed the sinus communicating with the iliac fossa.

I then opened extraperitoneally an abscess cavity lying on the ventor of the ilium, lined with granulation tissue, necrotic muscle and bone. It extended mesially to the transverse processes of the vertebræ and upwards along the psoas muscle. The situation, the destruction of the psoas muscle and ilium suggested tuberculosis rather than a lesion of appendiceal origin. However, the tissue removed showed actinomyces and filaments were also found in a Rosenow blood culture. Consequently potassium iodide was given orally and X-ray treatment commenced. In view of Osborne's findings, no iodide was given intravenously, as it was felt that a more constant concentration in the blood could be maintained by oral administration in divided doses.

The drainage persisted, being of a reddish-muddy type, about one to two drachms daily. The temperature ranged from 99 to 101. There was a constant leucocytosis (December 20th, 12,000; 78 per cent. polymorphonuclears. February 2nd, 22,660; 89 per cent. polymorphonuclears). During the last month he suffered greatly, and he became almost childish mentally, with progressive loss of strength and flesh, until he died on March 1st, after an illness of five months.

Post-mortem examination performed by Dr. G. W. Lougheed, disclosed the origin of the trouble about the appendix. In this region there was a large mass, with numerous adhesions. In the base of this mass was situated the appendix, which was attached to the muscles and the peritoneum of the crest of the ilium. Surrounding this was a collection of dark greenish pus. The external wound connected with this, so that there should have been good drainage.

The *liver* was very much enlarged, extending to the umbilicus. *Left pleural cavity* contained about 200 c.c. of dark greenish purulent material. *Right pleural cavity* showed some recent pleuritis. *Pericardial cavity* contained 20 c.c. of straw-colored fluid. *Left lung;* Near the anterior portion of the lower lobe of the lung is an abscess cavity which had perforated into the pleura. The lung on section showed areas of consolidation and small abscess formation scattered throughout the lower lobe. *Right lung;* Small abscesses the size of a pea are scattered irregularly throughout the whole of the lung tissue. *Liver;* markedly increased in size, weight about 2800 grams, surface smooth, has a dull gray appearance and cuts with resistance; leaves grease on the knife. Scattered throughout the liver are numerous small nodular masses which are beginning abscess formations. The central veins are slightly congested. *Left kidney* larger than normal; capsule strips readily; cortex rolls out: has a grayish appearance; the pyramids are slightly congested; pelvis contains a slight increase in peripelvic fat. Scattered throughout the kidney substance are small abscesses the size of a pin's head. *Right kidney* similar to left. *Pancreas* apparently normal. *Suprarenals* show slight congestion. *Appendix* is about 3 inches in length; lower end thickened and is attached to brim of pelvis and situated in pocket of pus. The peritoneum around this area shows small yellowish areas of pus, probably spreading from the tip of the appendix. *Spleen* is increased in size. On section its surface has a dull red appearance. Some pulp on scraping; tuberculæ are not prominent. There is some evidence of perisplenitis present.

Microscopic Examination.—Section from the abscess cavity around the tip of the appendix shows tissue infiltrated with polymorphonuclears, lymphocytes, plasma cells and gathered together in granulomatous areas, in the centre of which are situated ray fungi. This fungus shows distinct rays with some clubs present. *Liver* shows irregular infiltration with these granulomatous areas, and numerous ray fungi present. *Spleen* shows infiltration of polymorphonuclear leucocytes and deep congestion. *Kidneys* show occasional colony of actinomyces, similar to liver. *Pancreas* is apparently normal. *Suprarenals* apparently normal. *Bowel* shows slight congestion. *Heart* muscle shows congestion, slight inflammatory infiltration

around the blood-vessels. No colonies found. Ray fungus scattered throughout the *Lungs,* rather irregular small abscesses, the centres of which show ray fungus. *Left lung* near the anterior free margin shows a perforation into the left pleural cavity, with necrosis of the lung tissue. *Left testicle* apparently normal, shows slight congestion.

Case II.—Cervical. L. B. Age thirty-nine. He had a swelling in the right submaxillary region, associated with a tender lower first molar tooth, from which pus was discharging through a sinus into the mouth. On extraction of the tooth examination of the pus revealed the ray fungus. Under large doses of potassium iodide the swelling in his neck diminished slightly, but a hard mass remained and was removed by operation.

Section of this showed the typical appearance of actinomycosis. He continued on treatment with iodide of potassium for a period of six months, at one time taking 320 grs. a day for about three weeks. At the end of six months he was apparently entirely free of the disease and treatment was discontinued. Five years have now elapsed without further manifestation of the disease, he is in splendid health, and I think we may consider that a cure has been effected.

Case III.—A male, aged forty; a town-dweller, sent into my service with a mass in the right iliac region, which developed slowly, and had an indurated, solid feeling to it, very closely simulating carcinoma of the cæcum. On making an incision some pus was evacuated, and drainage instituted; the pus showing the actinomyces fungus. He was some months in the hospital under iodide treatment, and left slightly improved. I am not able, however, to give the ultimate result.

Case IV.—Male, forty-five years of age, with actinomycosis of the left lung. Drainage instituted.

REFERENCES

[1] Lord: Jour. Amer. Med. Assoc., 1910, vol. iv.
[2] Wright: Jour. Med. Research, 1904–5, vol. xiii.
[3] Ransom: Med. Chir. Trans., 1892.
[4] Battle and Corner: Diseases of the Appendix Vermiformis, 1904, p. 164.
[5] Cope: Brit. Jour. Surg., 1915, vol. iii, p. 53.
[6] Brockman: Brit. Jour. Surg., 1923, vol. x, No. 40.
[7] Bevan: Jour. Amer. Med. Assoc., 1905, Nov. 11th.
[8] Brogden: Jour. Laboratory & Clin. Med., 1922, vol. viii, No. 3.

HERNIA THROUGH THE CONJOINED TENDON*

OR

HERNIA OF THE LINEA SEMILUNARIS

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This paper deals with a type of hernia which in its anatomy, significance to the individual, its prognosis and treatment, differs as much from the ordinary direct hernia as the latter does from indirect hernia. If any hernia lying to the inner side of the epigastric artery is considered a direct hernia, then this type of hernia is also direct, but if included among the direct hernias it would be necessary to divide the latter into two distinct sub-classes. To call them hernias of the linea semilunaris leads to some confusion, because they are located only at one point of the linea semilunaris. Apparently the most accurate designation would be " hernia through the conjoined tendon " using old terminology, or " the falx inguinalis " using the new. This calls attention to its location, and to the fact that the hernia perforates this portion of the abdominal wall and is not a diffuse yielding of it, as is the case with the typical direct hernia.

A brief reference to anatomy may not be out of place. When one opens the inguinal canal of a very muscular subject and removes the cremaster muscle, Hesselbach's triangle is exposed to view. Above, the lowermost fibres of the internal oblique have a thick abrupt margin; the lowermost fibres seem to me to extend inward and but slightly downward to end in the linea semilunaris, and have little connection with the conjoined tendon. The transversalis muscle emerges below the lower border of the internal oblique, and either quite covers or almost covers the space down to the inguinal ligament. These fibres arch downward and inward, and at their termination inward, there is an area at the inner side of the triangle of firm consistency which is called the conjoined tendon, or falx inguinalis. The weakest portion of this posterior wall, according to the anatomists consulted and clinical experience, is just mesial to the deep epigastric artery, and close to the inguinal ligament. Here, even in muscular subjects, muscle fibres may be deficient. When this is the case, the posterior wall is said to be made up of a fascia transversalis. In subjects of weak musculature, the lower portion of the transversalis is poorly developed, and its giving way marks the starting point of a direct hernia. As the hernia enlarges it spreads across the triangle to the edge of the rectus, and in such cases a conjoined tendon is a scarcely demonstrable structure. In subjects, however, with a strong musculature, one at times encounters an opening, usually circular in outline, in a well developed conjoined tendon, lying close to

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the rectus border, with Poupart's ligament below and to its outer side having a fairly firm fibrous margin made of conjoined tendon fibres.

This type of hernia is no doubt much less frequent in its occurrence than the ordinary direct variety, but is not by any means a surgical curiosity; all surgeons of experience with hernias must have encountered it a number of

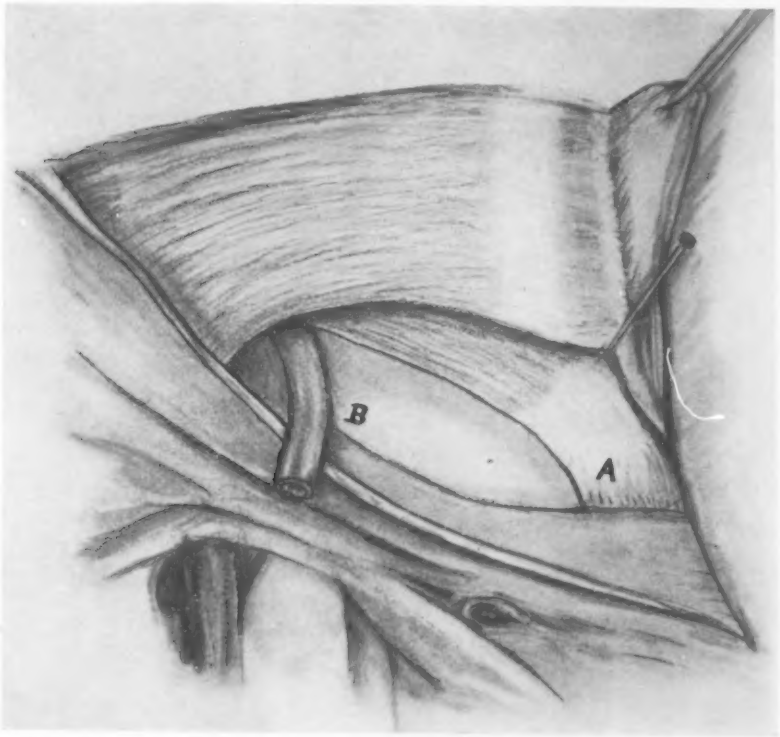

FIG. 1.—Semi-diagrammatic dissection of right inguinal region. *A*. Location of point of emergence of semilunar line hernia. *B*. Usual point of emergence of direct inguinal hernia.

times. In the preparation of this paper the writer has reviewed the records of eleven cases seen within the last three years at St. Luke's Hospital.

It is rather surprising that one sees so little reference to it in the literature. The older editions of Gray's Anatomy clearly contrast the two varieties, and suggest a different relation in the two cases to the obliterated hypogastric artery. Erdmann in a sentence says " direct hernia often emerges through a definite split in the fascia "; Downes clearly distinguishes the two types of hernia, calling the one direct and the other hernia of the linea semilunaris. He brings out both in the text and drawings the different locations and anatomical peculiarities of the two hernias. Most descriptions of direct hernia fail to mention this variety, hence are inaccurate when hernias of the conjoined tendon are included in the direct variety. The clinical side may be best presented by showing the points of similarity and contrast to direct hernia.

1. Neither direct nor conjoined tendon hernia is seen in children. Direct

hernia is practically confined to adult males. Conjoined tendon hernia is seen, but less frequently, in females.

2. Direct hernia has a wide and lax neck often difficult to define accurately. Conjoined tendon hernia has a small tight neck formed by the fibres of the tendon.

3. Conjoined tendon hernia is unilateral; direct hernia is usually bilateral, and is the result of muscular weakness.

4. Direct hernia may be associated on the same or opposite side with indirect hernia; the same has been observed in conjoined tendon hernias. I have even seen a conjoined tendon hernia associated with a fairly definite direct weakness.

5. One of the most important contrasts concerns the liability to strangulation, the small conjoined tendon hernia strangulating with the same ease as does the femoral hernia, while the direct hernia has little tendency to incarceration.

6. They vary also as regards the content of the hernia. The direct hernia may be said to always have a sac; conjoined tendon hernia may consist and frequently does consist only of a mass of prolapsing fat. The bladder is frequently present either with or without a true peritoneal sac.

7. In operating on direct hernia one often sees the obliterated hypogastric artery lying to the inner side of the sac, or arching over its inner portion. In conjoined tendon hernias the hypogastric cord, if seen, has usually been found on the outer side of the neck of the sac. In other cases with a true peritoneal sac present, the hypogastric cord has not been in evidence, but I have been able to satisfy myself that it must lie to the inner side of the hernia. The attempt to draw a distinction between the two types of hernia according to their relation to the hypogastric cord, has seemed to fail as an exact criterion, though it is probably true that the hypogastric nearly always lies to the inner side of a direct hernia, and frequently, at least, to the outer side of the conjoined tendon hernia.

8. The prognosis of conjoined tendon hernia is better and the treatment simpler than that of direct hernia.

9. This hernia presents an oval inguinal swelling quite similar to that of direct hernia, and lies beneath the external oblique aponeurosis, with the conspicuous difference that the swelling is unilateral and usually noted in muscular subjects.

10. As regards diagnosis it may be said that prior to operation, we have several times suspected the conjoined tendon variety and found it, but in a much larger number of cases have suspected this variety and found the diagnosis incorrect, operation revealing a direct hernia, or an ordinary inguinal bubonocele.

Of the eleven recent cases forming the basis of this report, the ages varied from 33 to 62 at the time of operation, the average being 43 plus years. The

bladder was present in the herniation a number of times, and was accidentally injured once.

The size of the hernia has varied, a number being quite small, the largest not larger than a hen's egg; four have been incarcerated or strangulated; two strangulated while in the hospital awaiting operation, and were operated upon in the course of a few hours; each contained a knuckle of small intestine. One patient, a woman aged forty, complained of a hernia in the left groin, which whenever it protruded, became very hard and painful, compelling her to lie down and maintain pressure until the swelling disappeared. Other conditions made an abdominal section necessary, at which a calcified tumor in the left ovary was discovered as large as a walnut. This could be readily pressed up into the hernial sac, which had a tight neck just admitting two fingers, and which lay to the inner side of the obliterated hypogastric.

One hernia of this group recurred promptly after operation. The patient was a man aged fifty, who had worn a truss for some years; for three days he had had a tender mass at the external ring, and there had been vomiting and general abdominal pain. Operation revealed a strangulated herniated mass protruding through an opening in the tendon three-fourths of an inch in diameter. The mass appeared to be inflamed fat; on investigating this mass in the search for a hernial sac, a cavity was found containing considerable turbid fibrinous fluid. A finger inserted into this cavity entered the abdomen; further investigation, however, showed that the finger had not entered the peritoneal cavity. A sound in the bladder demonstrated that that organ was not in the hernia, and that it had not been injured. The hernia then consisted of a mass of fat from the prevesical space which had become strangulated, with considerable fluid exudation both within the abdomen and outside the constricting ring. Three stitches closed the opening and a Bassini operation was added. A drain was left in the lower angle of the wound. The hernia has recurred and is partially controlled by a truss. The patient's lower abdomen is very fat and prominent.

This is the only recurrence in the group of eleven cases, but I recall another hernia of this type in a woman operated on more than ten years ago which required a subsequent operation, and so far as I know has since remained cured.

The treatment of this type of hernia is comparatively simple. One should be careful not to let a conjoined tendon hernia escape observation when operating for an indirect inguinal hernia. This might very well occur when the hernia is small in size, and would give one the impression later that the original hernia had recurred. When the opening is small, it is readily closed by one or more mattress sutures. At times the upper margin may be brought down to Poupart's ligament. One of the ordinary operations for strengthening the posterior wall of the canal may be added. The question comes as to what should be done with the hernias of larger opening, or recurrent hernias like the one mentioned above. In addition to closing the opening in the fascia, one might consider the lateral displacement of the rectus margin, suturing it

to Poupart's ligament, thus attempting to bring this muscle behind the opening in the conjoined tendon. Another possibility would be to fortify the opening by a reflected portion of the anterior rectus sheath. It would add additional security to this region if the cord were brought out superficial to the external oblique, with closure of the external abdominal ring.

REFERENCES

Gray's Anatomy, American Edition, 1887.

Inguinal Hernia in the Male, Seward Erdman, ANNALS OF SURGERY, vol. lxxvii, p. 171, February, 1923.

Management of Direct Inguinal Hernia, W. A. Downes, Archives of Surgery, vol. i, No. 1, p. 53.

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